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Calculating Available Safe Egress Time (ASET) - A Computer Program and User's Guide

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
Center for Fire Research
Washington, DC 20234

September 1982

Final Report



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TIME (ASET) - A COMPUTER
PROGRAM AND USER'S GUIDE**

Leonard Y. Cooper and
David W. Stroup

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

TABLE OF CONTENTS

	Page
LIST OF FIGURES	iv
NOMENCLATURE	v
Abstract	1
1. INTRODUCTION	2
1.1 Background	2
1.2 Some Basic Enclosure Fire Phenomena	4
1.3 An Overview of the Computer Program	6
1.4 Some Assumptions and Limitations	8
2. DESCRIPTION OF THE INPUT DATA	9
2.1 General Comments	9
2.2 General Data	11
2.3 Detection Criteria	14
2.4 Hazard Criteria	16
2.5 Room Characteristics	18
2.6 Fire Data: Energy Generation Rate	18
2.7 Fire Data: Detectable Product of Combustion Generation Rate	24
2.8 Fire Data: Hazardous Product of Combustion Generation Rate	27
3. DATA INPUT EXAMPLES	30
3.1 Example 1 - A Constant Size Fire	30
3.2 Example 2 - A Semi-Universal Growing Fire Hazard	42
3.3 Example 3 - Flashover Potential Due to a Fire in an Assembly of Bedding Combustibles	53
4. FUTURE EFFORTS	69
5. REFERENCES	71
APPENDIX A: PROGRAM DESCRIPTION	72
General Comments	72
MAIN Program	72
EXFIRE Subroutine	74
FUNQ Subroutine	74
FUNPRD Subroutine	74
FUNPRH Subroutine	75
SUBAINT Subroutine	75
INTGR Subroutine	76
SUBF Subroutine	76
INPUT Subroutine	77
INPUT2 Subroutine	77
APPENDIX B: PROGRAM LISTING	78

LIST OF FIGURES

	Page
Figure 1. Simple illustration of fire-in-enclosure flow dynamics . .	121
Figure 2. Computer output from batch run of Example 1	122
Figure 3. Computer output from batch run of Example 2	124
Figure 4. Computer output from batch run of Example 3	128
Figure 5. Example 3 results: plot of time to reach potential flashover against enclosure floor area, for a fire confined to an assembly of bedding combustibles	131

NOMENCLATURE

A	area of enclosure
ASET	Available Safe Egress Time
$\dot{C}$	rate of generation of a combustion product
H	height of enclosure ceiling above fire
M	concentration of a combustion product
$\dot{Q}$	rate of fire's energy release
RSET	Required Safe Egress Time
T	temperature
t	time
t_{DET}	time at detection
t_{HAZ}	time at onset of hazardous conditions
u_c	dimensional unit of a product of combustion
Z_i	elevation of interface
Δ	height of fire above floor
λ_c	fraction of $\dot{Q}$ transferred to enclosure surfaces
λ_r	fraction of $\dot{Q}$ radiated from combustion zone

Computer Program pages where

Input Variables defined

AKAP(I)	19, 21
ALAMC	12
ALAMR	12
BETAD	26
BETAH	28
CNDS(I)	14
CNHS(I)	16
DELTA	12
FIRE	18

HCOMB	23
HF(I)	17
PRD(I)	25-27
PRH(I)	28, 30
PRODD	24-25
PRODH	27-28
PRDØ*	25-26
PRHØ	28-29
Q(I)	19-20, 23
QØ	19-20, 23
RRDSPF(I)	14
SF(I)	17
TAULIM	20
TAUPRD(I)	25-26
TAUPRH(I)	28-29
TAUQ(I)	19, 23
TITLE	11
TMDSPF(I)	14
TMHSLF(I)	15
TMHSUF(I)	15
WRC	11
ZEYEF	12

* In this paper, the symbol Ø, appearing in a variable name, will be used to indicate the number 0, and the symbol 0, appearing in a variable name, will be used to indicate the letter O.

CALCULATING AVAILABLE SAFE EGRESS TIME (ASET) -
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Abstract

In the event of a fire in a building compartment the time available for occupants to safely evacuate the compartment, the Available Safe Egress Time (ASET), depends on the time of fire detection and on the time of the onset of hazardous conditions. In order to estimate these two times a dynamic simulation of the developing fire environment in the compartment is required. Also required are specific criteria for the simulation of detection and onset of hazard. A user oriented computer program which carries out the required simulations and provides estimates for the ASET has been developed. This document provides a listing of the program and a manual for its use. For fire growth in a particular fuel assembly, a single program run can be used to evaluate the ASET from enclosures (which are assumed to contain the fuel assembly) of different heights and areas, and under a variety of different detection and hazard criteria. The program can be used in either an interactive or batch mode. It is written in ANSI FORTRAN and requires no computer specific subroutines.

KEY WORDS: Combustion products; compartment fires; egress; fire detection; fire growth; hazard analysis; mathematical models; room fires; smoke movement; tenability limits.

1. INTRODUCTION

1.1 Background

The concept of life safety in buildings through designed safe egress has been introduced in references [1]-[4]*. The basic idea of the concept is that occupants of a building will be safe under fire conditions provided they will be able to successfully egress from threatened spaces prior to the time, t_{HAZ} , when hazardous conditions start to prevail. It is evident that occupants can only be expected to initiate an egress activity subsequent to the time, t_{DET} , of detection of the fire. The Available Safe Egress Time (ASET) is, therefore, simply computed as the time interval between detection and the onset of hazard. Thus, $ASET = t_{HAZ} - t_{DET}$.

If a building design is to be considered safe, from this standpoint the ASET from each of the building spaces which may be threatened must be longer than the time actually required for people to successfully evacuate these spaces. These latter time intervals are referred to as the Required Safe Egress Times (RSET). Thus, according to the Designed Safe Egress concept, in the event of a fire a building is safe if $ASET > RSET$ for all threatened spaces.

A general methodology for computing the ASET was discussed in reference [1] and [4]. The basic outline of the methodology is:

1. Identify the burning characteristics of fuel assemblies (combustible contents) exposed to likely ignition scenarios which are typical of the occupancy of interest. Provide a physical description of the building spaces.

*Numbers in brackets refer to literature references at the end of this paper.

2. Use an appropriate enclosure fire model to simulate analytically the dynamic environment which evolves in each building space.
3. Identify criteria for fire detection and onset of hazard. These would be compatible with the characteristics of existing detection hardware and the characteristics of likely building occupants, respectively.
4. Apply the criteria of No. 3 to the computed environment of No. 2, and thereby estimate t_{DET} and t_{HAZ} for the threatened spaces. Compute $ASET = t_{HAZ} - t_{DET}$.

For a single compartment of fire origin, a simple enclosure fire model which could be used in the above computation procedure was presented in [1] and [2]. A user oriented computer program which carries out the procedure with this model has been written. It is the purpose of this document to provide a listing of the program and a manual for its use.

The computer program described here can be used to study many features of enclosure fires. However, the program was specifically designed to answer questions related to life safety in fires. For this reason this work makes frequent use of terminology derived from the word "hazard." In this regard, it is not the intent of the authors to ascribe any precise definition to this terminology, and in many cases it would have been possible to have substituted terminology derived from words such as "untenable," "risk," etc. Hopefully the meaning of the "hazard" terminology will be clear from the context of its use.

1.2 Some Basic Enclosure Fire Phenomena

To use the program successfully, a user should be familiar with some basic enclosure fire phenomena. These are illustrated in figure 1.

A fire is initiated in a fuel assembly which is contained by an enclosure whose ceiling is a distance H above the base of the fire, and whose area is A . The base of the fire is a distance, Δ , above the floor. An estimate of the total energy release rate of the fire, $\dot{Q}$, as a function of time, t , is assumed to be available, as is the fire's generation rate $\dot{C}$ of a product of combustion of interest (e.g., for the purpose of establishing detection or hazard). In practice it is recommended that the free burn energy release rate and product generation rate be used as surrogates for $\dot{Q}$ and $\dot{C}$, respectively. (An estimate of these free burn characteristics will be the basis of a portion of the program input data.) In this paper, free burn is defined as "a burn of the fuel assembly in a large (compared to the combustion zone) ventilated space which contains a relatively quiescent atmosphere."

As the fire develops from ignition, buoyancy forces drive the high temperature products of combustion upward toward the ceiling. In this way a plume of upward moving elevated temperature gases is formed above the fire. All along the axis of the plume, relatively quiescent and cool ambient air is laterally entrained and mixed with the plume gases as they continue their ascent to the ceiling. As a result of this entrainment the total mass flow rate in the plume continuously increases, and the average temperature and average concentration of products of combustion in the plume continuously decreases with increasing height.

When the plume gases impinge on the ceiling, they spread across it forming a relatively thin, stably stratified upper layer. As the plume gas upward filling process continues, the upper gas layer grows in depth, and the relatively sharp interface between it and the cool ambient air layer below continuously drops.

In the model being used to describe the above phenomena it is assumed that at every instant of time a fully mixed upper gas layer is a reasonable approximation to the actual state of affairs. Accordingly, the model provides a time-dependent description of the environment in the enclosure by predicting the elevation, $Z_1(t)$, of the interface (or the upper layer thickness), the upper layer temperature, $T(t)$, and the combustion product concentration, $M(t)$. It is with the use of the computed histories of these variables and with required input data, to be described below, that the computer program proceeds to establish and invoke appropriate hazard and detection criteria.

1.3 An Overview of the Computer Program

In the computer program, input data describing the fire's elevation, and energy and product of combustion generation rates are used together with enclosure size (height and area) and user specified detection and hazard criteria to determine t_{DET} , t_{HAZ} , and the ASET. The ambient temperature at the initiation of all fire scenarios is taken to be 21.1°C (70°F).

For detection criteria, the user can specify a detectable upper smoke layer temperature, rate-of-temperature rise or concentration of a detectable product of combustion. Instantaneous detection may be specified by inputting a zero or "small" detectable upper smoke layer temperature or rate-of-temperature rise.

When the smoke layer interface is above some characteristic, user-specified face elevation, hazard is assumed to occur if and when a hazardous radiation exposure from the upper layer is attained. Such an exposure is defined by a critical, user-specified, upper layer temperature. If the interface is below face elevation, then hazard is assumed to occur if and when a second, critical, user-specified upper layer temperature is attained. However, the latter critical temperature would be lower than the former one, and hazardous conditions are now initiated as a result of direct burns or inhalation of hot gases. When the interface has dropped below face elevation, hazard is also assumed to occur if and when a critical, user-specified concentration of some hazardous product of combustion is attained.

The program allows the user to model the energy generation rate of the fire (fire growth) by either one of two methods. The first method uses continuous, user-specified, exponential growth curve segments. The other method uses pairs of user-specified data points (energy generation rate, time) with linear interpolation between them. Either of these methods would be used to describe the time-varying energy release rate of the free burning fuel assembly whose hazard is being evaluated. There would be different types of data inputs required depending on which model is chosen.

The computer program allows the user to model a product of combustion generation rate of the fire by one of two methods. The model of the first method is defined by an unchanging, user-specified constant of proportionality between the product of combustion generation rate and the previously specified energy generation rate. The other method uses pairs of user-specified data points (product generation rate, time) with linear interpolation between them. The product generation rate is specified in units of u_c per unit time, where u_c is a dimensional unit appropriate for the particular product. For example, u_c could have the dimension of mass, number of particles, etc.

The program has a capability of modeling up to two different product of combustion species, and of simulating their respective upper layer concentrations. The first of these is a product whose upper layer concentration would be the basis of a detection criterion, and the second is a product whose concentration would be the basis of a hazard criterion. In general, the fire's generation rate of each of these products would be modeled differently, according to either of the two methods described above, and each with its appropriate u_c .

For a user specified fire type and elevation above the floor, a single computer run of the program can be used to evaluate the ASET which corresponds to each of a multiple number of enclosure sizes and pairs of detection and hazard criteria.

By solving the mathematical fire modeling equations outlined in reference 2, the program simulates the changing environment (thickness, temperature, and product concentration of the smoke layer) in the enclosure. At every time step into the simulation, the prevailing conditions in the space are checked against the detection and hazard criteria being invoked. In this way the times t_{DET} and t_{HAZ} , corresponding to every room geometry and to each pair of detection and hazard criteria, are eventually identified. The ASETs are computed and displayed in the computer output along with other potentially useful results of the computations. Each simulation continues in time until the onset of hazard or until a maximum, user-specified time is attained. If detection has not occurred by the time of the onset of hazard in a given simulation, then detection is assumed to occur simultaneously with onset of hazard, and the computed ASET is zero.

1.4 Some Assumptions and Limitations

The assumptions and limitations of the fire model are presented and discussed in [1] and [2]. The user of the program is referred to those references for a complete treatment of the concepts and equations used in the development of this computer program. A few of the more significant of the assumptions and limitations are:

1. The computer model may not be reliable when applied to enclosures with length-to-width aspect ratios greater than 10:1, or with a ratio of height to minimum horizontal dimension exceeding one.

2. All doors, windows, and other significant partition penetrations to adjacent spaces are assumed to be closed. However, prior to the onset of hazardous conditions, sufficient oxygen is assumed to be available for free-burning combustion.
3. The enclosure is assumed to be divided into two horizontal layers with a sharp interface separating an elevated temperature, products of combustion contaminated "smoke" mixture above, from cool ambient air below. The upper layer is assumed to be uniformly mixed. The computer model is not reliable once the upper layer temperature exceeds a level of approximately 350-450°C, at which time radiation feedback to the fuel will significantly alter the initial free-burn-like behavior of the fire.
4. Some leakage from the room is inevitable. This leakage is assumed to occur through leakage paths close to the floor. Thus, at least up to the time that the interface drops to the floor, it is assumed that the enclosure will leak cool ambient air at low elevation rather than, say, elevated temperature products of combustion at a near-ceiling elevation.

2. DESCRIPTION OF THE INPUT DATA

2.1 General Comments

This program has been designed to be useable in either an interactive or batch mode. When in the interactive mode, the program guides the user through the data input process.

The data input has been divided into the following seven elements:

General Data

Detection Criteria

Hazard Criteria

Room Characteristics

Fire Data: Energy Generation Rate

Fire Data: Detectable Product of Combustion Generation Rate

Fire Data: Hazardous Product of Combustion Generation Rate

The input data described here will be the same for both the interactive and batch modes. Extra input data may be required in the interactive mode to answer error check and "Pause" questions. The basic required input data are described in detail in the next seven sections. Each line started by CARD indicates a line of input data at a computer terminal or a computer punch card. Where the CARD is followed by (S), this indicates that there may be more than one card or line used if necessary. Numerical values should be placed as indicated by their variable names. Unless otherwise stated, this data may be entered unformatted, that is, numbers do not have to be placed in specific card columns. Different numerical values entered on the same computer punch card or line (at a computer terminal) must be separated by either a comma or a blank. When information is contained in parentheses on the CARD line, this indicates the range of values which may be substituted for the particular variable. The data is described in the order in which it must be entered into the program.

2.2 General Data

CARD: TITLE

This card should contain the title for the run. It may be any string of up to 80 characters which describes the particular computer run.

CARD: WRC (WRC = 1, 2, 3 or 4)

WRC = 1, summary output. Only the fire environment characteristics at detection and hazard, and egress time will be printed.
(132 characters per line)

WRC = 2, summary output. (80 characters per line)

WRC = 3, full output. The time-temperature-layer thickness-rate of rise-concentration history will be printed along with summary output. (132 characters per line)

WRC = 4, full output. (80 characters per line)

The write code, or output code, is used to determine whether full or only limited output should be printed. The write code will be an integer value of 1, 2, 3, or 4. It should be chosen based on the amount of information the user desires and the printing capability of the user's computer. If a 1 is selected, summary output, which includes the times of detection and hazard, descriptions of the room environments at these times, and the ASET from the space, will be printed. The enclosure environment descriptions

include the temperature, thickness, products of combustion concentrations and interface elevation of the smoke layer. In addition, the detection and hazard criteria being considered are printed along with the height and area of the room. This information will be printed using 132 characters per line. Output form 2 will print the same information using 80 characters per line. If output form 3 is chosen, then in addition to summary output the entire history of the fire will be printed. In this case, the state of the fire environment is displayed at specified instants of time which span the entire time frame of the simulation. In particular, at five second intervals the computed values of the fire's energy generation rate (normalized by the rate at ignition if desired) and the smoke layer's thickness, interface elevation, temperature, rate-of-temperature rise and combustion product concentrations are provided in a single line of output. This line will be 132 characters long. Output type 4 will print the same information as type 3, but the lines will be 80 characters long.

CARD: ALAMR, ALAMC, ZEYEF, DELTA

ALAMR - the fraction of the fire's energy generation rate instantaneously lost by radiation from the combustion zone and plume.

ALAMC - the fraction of the fire's energy generation rate instantaneously lost to the bounding surfaces of the room and its contents.

ZEYEF - the specified characteristic height, in feet, of eyelevel from the floor.

DELTA - the height, in feet, of the base of the fire above the floor.

This last card in the general data group should contain four values. There should be one value for each of the above variables. A determination of the appropriate values to substitute for these variables must be made by the user.

ALAMR is the parameter λ_r of [2]. As defined above, it is the fraction of the fire's energy release rate which is instantaneously lost by radiation from the combustion zone. The value $(1-\lambda_r)$ is used in the program to determine the fraction of the energy release rate which effectively acts to drive the fire plume's upward momentum. In [2] it is concluded that $\lambda_r = 0.35$ is a reasonable choice for typical, hazardous, flaming fires.

ALAMC is the parameter λ_c of [2] and [4], and it is defined as the instantaneous fraction of the energy release rate which is lost to the bounding surfaces of the room and its contents. The total rate of energy loss which is characterized by λ_c occurs as a result of a variety of different convective and radiative heat transfer exchanges between the room's gases and the above mentioned surfaces. It is not presently possible to obtain an exact value for λ_c . (Indeed, although λ_c is taken as a constant, it is, in fact, a time-varying parameter.) However, using $\lambda_r = 0.35$, it is concluded in the Appendix of [4] that during the early stages of fires in single rooms the value of λ_c is relatively constant and in the range 0.6 - 0.9. The lower, 0.6 value, would relate to high aspect ratio spaces (ratio of ceiling span to room height) with smooth ceilings and with fires positioned far away from the walls. The intermediate values and the high, 0.9 value for λ_c would relate to low aspect ratio spaces, fire scenarios where the fire position is within a room height or so from walls, and/or to spaces with highly irregular ceiling surfaces. Some further guidelines on an appropriate choice for the value of λ_c are presented in [2].

The user must specify a value for ZEYEF, the characteristic height, in feet, of eyelevel from the floor. This value is important because it has significant effect on how and when hazard occurs. When the smoke layer interface is above eyelevel (or facelevel), hazard could occur due to downward directed radiation produced by an excessively high smoke layer temperature which exceeds some critical temperature (to be specified below). When the smoke layer interface is below eye elevation, then hazard could occur due to inhalation of gases with an excessive concentration of some hazardous product of combustion or due to direct burns and inhalation of hot gases whose temperature exceeds a second critical upper layer temperature. The latter critical temperature would be lower than the former one. The specified value for ZEYEF does not necessarily have to be the "true" height of eyelevel, but its value must be chosen as not greater than the room height or less than zero. An appropriate value would be one which indicates a likely change in potential mode of hazard initiation from radiation from the upper layer to visual obscuration.

The value specified for DELTA, the height, in feet, of the base of the fire above the floor should be according to the user's understanding of the physical conditions under investigation.

2.3 Detection Criteria

CARD(S):TMDSPF(I)

TMDSPF - the upper layer temperature, in degrees F, which will initiate detection.

CARD(S):RRDSPF(I)

RRDSPF - the upper layer rate-of-temperature rise, in degrees F per minute, which will initiate detection.

CARD(S):CNDS(I)

CNDS - the concentration of the detectable product of combustion, in units of u_c per gram of bulk upper layer gas, which will initiate detection. (See discussion below under Fire Data: Detectable Product of Combustion Generation Rate.)

Any or all of the above detection criteria may be used, and there may be from zero to as many as ten different values entered for each mode of detection. Use of at least one criterion and one entry is required. (Note that one possible way of specifying immediate detection, i.e., detection at the time of ignition, is to specify detection when the smoke layer's rate-of-temperature rise exceeds zero degrees F per minute.) When using a computer terminal, input each value separately until all desired values for a particular detection mode have been entered. When all values for a particular mode of detection have been entered, type an end of file mark (UNIVAC: @EOF). If data is to be entered using cards, type each value on a different card. A card containing an end of file mark should separate each set of values for a particular detection criterion.

The program uses the elements of the list of input values for each detection mode, one at a time, to determine the time of detection in a given fire scenario.

2.4 Hazard Criteria

CARD(S):TMHSUF(I)

TMHSUF - the hazardous temperature, in degrees F, of the smoke layer when the interface is above eyelevel.

CARD(S):TMHSLF(I)

TMHSLF - the hazardous temperature, in degrees F, of the smoke layer when the interface is below eyelevel.

CARD(S):CNHS(I)

CNHS - the concentration of the hazardous product of combustion, in units of u_c per gram of bulk upper layer gas, which will initiate a hazardous condition when the interface is below eyelevel.

A minimum of one and a maximum of ten different values may be entered for each of the three modes of hazard. All combinations of the hazard mode entries will be considered, and each of the combinations will be used, one at a time, to determine the time to hazard in a given fire scenario. For example, assuming one entry for TMHSUF, three entries for TMHSLF, and two entries for CNHS, then one of the six ($1 \times 3 \times 2 = 6$) overall criteria for hazard that will be invoked will be:

Onset of hazard occurs when

the upper layer temperature is greater than TMHSUF(1), AND the layer interface elevation is greater than ZEYEF,

OR the upper layer temperature is greater than TMHSLF(2), AND the layer interface elevation is less than ZEYEF,

OR the upper layer concentration of the combustion product is greater than CNHS(2), AND the layer interface elevation is less than ZEYEF.

Hazard criteria input data should be entered in the same way as detection criteria input data, with each of the three lists of hazard mode entries terminating with an end of file mark (UNIVAC: @EOF).

The critical temperature values assigned by the input TMHSUF(I) are directly related to those temperatures of overhead smoke layers which would supply a potentially hazardous flux of downward directed thermal radiation. A TMHSUF value of 361, i.e., 183°C (361°F), has been recommended in [1]. Assuming that an upper layer radiates as a black body and with a view factor of 1, this temperature would correspond to a flux of 2.5 kW/m^2 , which has been identified as a flux level near the threshold of human tenability [5].

Once the interface is below "eyelevel", the new critical upper layer temperature, input as TMHSLF, will generally be significantly less than TMHSUF. Hazard would now occur on account of direct external or internal (due to inhalation of hot gases) burns. Realistic values of TMHSLF would likely be of the order of 212, i.e., 100°C (212°F).

With the interface below eyelevel, hazard could also occur as a result of a high concentration (in excess of the critical value, CNHS) of the hazardous product of combustion, e.g., on account of the product's toxicity. If one does not wish to invoke this aspect of the overall hazard criterion, then at this

stage of the input the user simply enters any single positive value for CNHS. At the appropriate place, to be described below, the user would then enter input data that models the hazardous product generation rate as identically zero.

2.5 Room Characteristics

CARD(S):HF(I)

HF - the height, in feet, of the compartment

CARD(S):SF(I)

SF - the floor area, in square feet, of the compartment

At least one height and one area must be specified. The program can handle as many as twenty room heights and thirty areas during one run, and rooms defined by all combinations of the HF(I) and SF(I) entries are evaluated.

The room data should be entered in the same way as the detection and hazard data, with each of the HF and SF entry lists terminating with an end of file (UNIVAC: @EOF).

2.6 Fire Data: Energy Generation Rate

The first card in this fire data series determines how the energy generation rate of the fire, $Q(t)$, will be modeled and what input data will be required. The variable FIRE may be assigned an integer value of 1, 2, or 3. Two types of fire growth models, requiring different forms of input data, have been included in the computer program. The third available location (FIRE = 3) has been left so that a user can add another fire modeling subroutine, if desired.

CARD:FIRE (FIRE = 1, 2, or 3)

FIRE = 1, a multi-exponential energy generation rate curve made up of NSEQQ continuous segments of the form:

$$Q(t) = \begin{cases} Q(1)\exp\{AKAP(1)t\}, & \text{1st segment,} \\ 0 \leq t < TAUQ(1); \\ Q(2)\exp\{AKAP(2)[tTAUQ(1)]\}, & \text{2nd segment,} \\ TAUQ(1) \leq t < TAUQ(2); \\ \vdots \\ Q(NSEQQ1)\exp\{AKAP(NSEQQ1)[tTAUQ(NSEQQ-2)]\}, & \text{(NSEQQ1) segment,} \\ TAUQ(NSEQQ2) \leq t < TAUQ(NSEQQ1); \\ Q(NSEQQ)\exp\{AKAP(NSEQQ)[tTAUQ(NSEQQ1)]\}, & \text{NSEQQth segment,} \\ TAUQ(NSEQQ1) \leq t \end{cases}$$

where the NSEQQ values, $Q(1)$, $Q(2)$, . . . , $Q(NSEQQ)$, and the NSEQQ values, $AKAP(1)$, $AKAP(2)$, . . . , $AKAP(NSEQQ)$ are supplied as input.

FIRE = 2, an energy generation rate curve made up of NSEQQ continuous linear segments. The curve would be defined by

$$Q(t) = \begin{cases} Q\emptyset & \text{at } t = 0; \\ Q(1) & \text{at } t = TAUQ(1); \\ \vdots \\ Q(NSEQQ) & \text{at } t = TAUQ(NSEQQ) \end{cases}$$

with linear interpolation between the above NSEQQ + 1 data points. As described below, $Q\emptyset$ and the NSEQQ pair of values $TAUQ(1)$, $Q(1)$; $TAUQ(2)$, $Q(2)$; . . . ; $TAUQ(NSEQQ)$, $Q(NSEQQ)$ are supplied as input.

FIRE = 3, not used (space left available for a user developed subroutine describing the fire's energy generation rate).

Multi-exponential curve:

If a multi-exponential energy generation rate curve is selected (FIRE = 1), then the following input entries will be required:

CARD:TAULIM

TAULIM - the maximum time for which the fire environment will be simulated.

CARD(S):Q(I),AKAP(I)

Q(I) - the value of the energy generation rate, in kW, at the beginning of the Ith segment of the multi-exponential growth curve. All Q(I) must be greater than zero.

AKAP(I) - the value of the exponential growth factor, in units of 1/second, for the Ith segment.

The NSEQQ pairs of data should be entered one pair at a time. The user may enter as many as 100 pairs of data. After the last pair of data has been entered, an end of file mark (UNIVAC: @EOF) should be entered.

CARD: (YES OR NO) - NORMALIZED OUTPUT

If desired, the fire energy generation rates may be printed in normalized form, $Q(t)/Q(1)$.

The following example will clarify the data input required for a multi-exponential fire:

Assume that the growth of a fire in some typical fuel assembly has the following characteristics:

Fire ignition source is 10 kW (e.g., fire in a wastepaper basket).

Fire grows exponentially from 10 kW to 400 kW with an exponential growth factor of 0.025/s (i.e., the fire doubles in power output every 27.7 s).

Fire grows exponentially from 400 kW to 3000 kW with an exponential growth factor of 0.010/s (a doubling time of 69.3 s).

Fire continues to grow exponentially from 3000 kW to an unknown peak value with an exponential growth factor of 0.005/s (a doubling time of 138.6 s).

Assume further, that for whatever reason the environment which develops within the fire enclosure will never be of interest beyond the first 1200 s following ignition.

Then the Fire Data: Energy Generation Rate set of inputs should appear as follows (for a UNIVAC computer):

```

CARD:1
CARD:1200
CARD:10.,0.025
CARD:400.,0.010
CARD:3000.,0.005
CARD:@EOF
CARD: YES - NORMALIZED OUTPUT

```

and the program will compute $Q(t)$ according to

$$Q(t) = \begin{cases} 10 \exp\{0.025t\}, & 0 \leq t < 147.6 \\ 400 \exp\{0.010[t-147.6]\}, & 147.6 \leq t < 349.1 \\ 3000 \exp\{0.05[t-349.1]\}, & 349.1 \leq t \end{cases}$$

where t is in seconds. Note that the segment end-points at 147.6 s and 349.1 s were not entered as input data. Rather, the program itself computes these times from the requirement that the three exponential segments form a continuous energy generation rate curve.

Linear Segmented Curve

If a linearly segmented fire growth curve is selected ($FIRE = 2$), then the following input entries will be required.

```
CARD:TAULIM, HCOMB
```

TAULIM - the maximum time for which the fire environment will be simulated.

HCOMB - the effective heat of combustion, in kilojoules per kilogram, of the fuel assembly. This multiplier is used to convert input data in the form of fuel assembly mass loss rate (kilograms per second) to energy generation rate, in kW. If the input data to be described below is given directly in kW, then HCOMB = 1.0.

CARD:QØ

QØ - the initial energy generation rate of the fire.

CARD(S):TAUQ(I),Q(I)

TAUQ(I) - the value of time, in seconds, at the end of the Ith segment of the energy generation rate curve (or mass loss rate curve, if HCOMB $\neq$ 1.0).

Q(I) - the value of the energy generation rate, in kW, at the end of the Ith segment of the energy generation rate curve (or, the value of the mass loss rate, in kilograms per second, at the end of the Ith segment of the mass loss rate curve, if HCOMB $\neq$ 1.0).

Each data point should be entered on a separate card or line at a computer terminal. In total, there will be NSEGQ data points entered. The user may enter as many as 100 data points. The value of TAUQ(NSEGQ) should be greater than or equal to TAULIM. After the last data point has been entered, type an end of file mark (UNIVAC:@EOF).

CARD: (YES OR NO) - NORMALIZED OUTPUT

If desired, the fire energy generation rates may be printed in normalized form, $Q(t)/QØ$.

2.7 Fire Data: Detectable Product of Combustion Generation Rate

No input should appear in this set if there were no entries for CNDS in the Detection Criteria set. Under such a circumstance, the user should now go directly to the next set of inputs, Fire Data: Hazardous Product of Combustion Generation Rate.

Provided that there is at least one entry for CNDS in the Detection Criteria set, the first card in this set will establish how the fire's detectable product of combustion generation rate, $\dot{C}(t)$, will be modeled, and what subsequent input data will be required. The variable PRODD may be assigned an integer of 1, 2, or 3. Two types of product generation rate models, requiring different forms of input data have been included in the computer program. A third available location (PRODD = 3) has been left so that a user can add another product generation rate model subroutine, if desired.

The product generation rate, $\dot{C}(t)$, is specified in units of u_c per second, where u_c is a dimensional unit which is appropriate for the particular combustion product being generated. For example, if u_c is taken as mass in grams, then $\dot{C}(t)$ must be described in dimensions of grams (of product) per second; if u_c is taken as number of particles, then $\dot{C}(t)$ must be described in units of number of particles (of product) per second; etc.

The choice of the units u_c will have direct impact on the dimensionality of the computed upper layer product concentration, $M(t)$. As discussed earlier, the program computed $M(t)$ in units of u_c per gram of bulk upper layer mixture. Thus, if u_c is in grams, and $\dot{C}(t)$ is in grams per second, then $M(t)$

will be computed in units of grams (of detectable combustion product) per gram of bulk upper layer mixture; if u_c is in number of particles, and $\dot{C}(t)$ is in number of particles per second, then $M(t)$ will be computed in units of number of particles (of detectable combustion product) per gram of bulk upper layer mixture; etc.

CARD:PRODD(PRODD = 1, 2, or 3)

PRODD = 1, detectable product generation rate is directly proportional to the energy generation rate through a fixed constant, BETAD, i.e., $\dot{C}(t) = \text{BETAD} \cdot \dot{Q}(t)$.

PRODD = 2, a product generation rate curve made up of NSEGPD continuous linear segments. The curve would be defined by

$$\dot{C}(t) = \begin{cases} \text{PRD}\emptyset & \text{at } t = 0; \\ \text{PRD}(1) & \text{at } t = \text{TAUPRD}(1), \\ \vdots & \\ \text{PRD}(\text{NSEGPD}) & \text{at } t = \text{TAUPRD}(\text{NSEGPD}) \end{cases}$$

with linear interpolation between the above NSEGPD + 1 data points. As described below, PRD $\emptyset$ and the NSEGPD pair of values TAUPRD(1), PRD(1); TAUPRD(2), PRD(2);; TAUPRD(NSEGPD), PRD(NSEGPD) are supplied as input.

PRODD = 3, not used (space left available for a user developed sub-routine describing the product generation rate).

Constant Proportionality:

If a fixed constant of proportionality for the product generation rate is selected (PRODD = 1), then a value for BETAD must be provided as follows:

CARD:BETAD

BETAD - a constant of proportionality between the detectable product of combustion generation rate and the energy generation rate, i.e.,
 $\dot{C}(t) = \text{BETAD} \cdot \dot{Q}(t)$. BETAD is entered in units of u_c per second per kW.

Linear Segmented Curve:

If a linear segmented product generation rate is selected (PRODD = 2), then the following input entries will be required:

CARD:PRDØ

PRDØ - the initial detectable product generation rate in units of u_c per second.

CARD(S):TAUPRD(I), PRD(I)

TAUPRD(I) - the value of time, in seconds, at the end of the Ith segment of the detectable product generation rate curve.

PRD(I) - the value of the product of combustion generation rate, in units of u_c per second, at the end of the Ith segment of the product generation rate curve.

Each data point should be entered on a separate card or line at a computer terminal. In total, there will be NSEGPD data points entered. The user may enter as many as 100 data points. The value of TAUPRD(NSEGPD) should be greater than or equal to TAULIM. After the last data point has been entered, type an end of file mark (UNIVAC: @EOF).

2.8 Fire Data: Hazardous Product of Combustion Generation Rate

Input data describing a hazardous product of combustion generation rate curve must be included in this set.

The first card in the set will establish how the fire's hazardous product generation rate, $\dot{C}(t)$, will be modeled, and what subsequent input data will be required. The variable PRODH may be assigned an integer of 1, 2, or 3. Two types of product generation rate models, requiring different forms of input data have been included in the computer program. A third location (PRODH = 3) has been left so that a user can add another product generation rate model subroutine, if desired.

The question of the units of $\dot{C}(t)$ has been addressed above in the initial discussion of Section 2.7 on the Detectable Product card set. That discussion is also relevant to the Hazardous Product dimensionality, and it should be revisited and applied in the present context.

CARD:PRODH (PRODH = 1, 2, or 3)

PRODH = 1, hazardous product generation rate is directly proportional to the energy generation rate through a fixed constant, BETAH, i.e., $\dot{C}(t) = \text{BETAH} \cdot \dot{Q}(t)$.

PRODH = 2, a product generation rate curve made up of NSEGPB continuous linear segments. The curve would be defined by

$$\dot{C}(t) = \begin{cases} \text{PRH}\emptyset & \text{at } t = 0; \\ \text{PRH}(1) & \text{at } t = \text{TAUPRH}(1), \\ . \\ . \\ \text{PRH}(\text{NSEGPB}) & \text{at } t = \text{TAUPRH}(\text{NSEGPB}). \end{cases}$$

with linear interpolation between the above NSEGPB + 1 data points. As described below, PRH $\emptyset$ and the NSEGPB pair of values TAUPRH(1), PRH(1); TAUPRH(2), PRH(2);; TAUPRH(NSEGPB), PRH(NSEGPB) are supplied as input.

PRODH = 3, not used (space left available for a user developed subroutine describing the product generation rate).

Constant Proportionality

If a fixed constant of proportionality for the product generation rate is selected (PRODH = 1), then a value for BETAH must be provided as follows:

CARD:BETAH

BETAH - a constant of proportionality between the hazardous product of combustion generation rate and the energy generation rate, i.e.,
 $\dot{C}(t) = \text{BETAH} \cdot \dot{Q}(t)$. BETAH is entered in units of u_c per second per kW.

If adequate quantitative information on hazardous product generation rate is unavailable, then the user may prefer to eliminate its consideration from the definitions of hazard criteria. This would most readily be accomplished by specifying $PROD_H = 1$, and $BETA_H = 0$ (i.e., the fire's hazardous product generation rate is specified to be zero, and the program computes a zero upper layer hazardous product concentration at every instant of time). As recommended at the end of Section 2.4, this default specification would be implemented together with an arbitrary positive value for $CNHS$.

Linear Segmented Curve:

If a linear segmented product generation rate is selected ($PROD_H = 2$), then the following input entries will be required:

CARD: PRH_0

PRH_0 - the initial hazardous product generation rate in units of u_c per second.

CARD(S): $TAUPRH(I)$, $PRH(I)$

$TAUPRH(I)$ - the value of time, in seconds, at the end of the I th segment of the hazardous product generation rate curve.

$PRH(I)$ - the value of the product of combustion generation rate, in units of u_c per second, at the end of the I th segment of the product generation rate curve.

The data points should be entered one at a time. There should be a total of NSEGPB data points, up to 100. An end of file mark (UNIVAC: @EOF) should follow the last data point.

3. DATA INPUT EXAMPLES

The following examples should aid in developing an understanding of what data is required by the program and how to enter this data into the runstream. The arrangement of input data will be described for both interactive and batch use. In the interactive examples, words spelled with all capital letters indicate information printed at a computer terminal by the computer program. The user's response is preceded by "ENTER:" and will always be in lower case letters and underlined. The batch input data will be listed as it would appear on a group of data cards. For each example, the interactive mode data input will be described first. This will be followed by the batch mode data, and, finally, the computer generated results will be presented. (These examples are from the National Bureau of Standards UNIVAC 1100/80 computer.)

In the interactive mode, "Pause" statements have been used at selected places to temporarily suspend printing of the computer generated results. This will enable the user to examine the results more carefully and make notes if desired. In order to continue program execution, the user must type a carriage return.

3.1 Example 1 - A Constant Size Fire

This example will deal with a problem of estimating the ASET from a room with a fire of constant energy release rate. This type of example is useful since many potentially threatening fires tend to release energy at an approximately constant rate for a significant time subsequent to ignition.

The problem is to estimate the ASET under the following fire scenario:

A fire due to a gasoline spill in a 8.9 ft^2 (0.83 m^2) dike is initiated on the floor of a room of height 10 ft (3.0 m) and area $10,000 \text{ ft}^2$ (929 m^2). The rate of the fire's energy release per unit area of spill is approximately constant at $140 \text{ BTU}/(\text{ft}^2 \text{ s})$ ($1.6 \text{ MW}/\text{m}^2$) [6] for a total energy release rate of 1250 BTU/s (1320 kW).

On account of the fact that occupants are likely to be awake and alert it is assumed that the fire is detected immediately after ignition. Put another way, detection is assumed to occur when the rate-of-temperature rise, RRDSPF , is zero.

The fire is assumed to be away from the walls, and the room has a relatively smooth ceiling. Based on remarks in section 2.2, the fraction of energy release instantaneously lost to the bounding surfaces of the room and its contents, ALAMC , is taken to be 0.6. Also, the fraction of the energy release instantaneously lost by radiation from the combustion zone, ALAMR , is taken to be 0.35.

The elevation of eyelevel will be taken as 4 ft (1.2 m). When the interface is above this height it is assumed that hazard will occur if and when the upper layer temperature rises to 361.4°F (183°C). Once the interface has dropped below the 4 ft (1.2 m) elevation it is assumed that onset of hazard will occur if and when the upper layer temperature reaches 240°F (115°C), or if and when the upper layer oxygen mass fraction is depleted from the oxygen mass fraction at ambient conditions ($0.23 \text{ g}_{\text{O}_2}$ per g of ambient air) to $0.18 \text{ g}_{\text{O}_2}$ per g of upper layer mixture. Thus, depleted oxygen is taken to be the hazardous product of

combustion, the unit u_c is taken to be grams of depleted oxygen, $g_{\text{depleted } O_2}$, and the hazardous concentration is taken to be $0.05 g_{\text{depleted } O_2} \text{ per } g_{\text{upper}}$ which corresponds to $CNHS = 0.05$.

Based on the work of Huggett [7], the rate at which oxygen is depleted in fires is approximately proportional to the fire's energy release rate according to

$$\dot{C}_{\text{depleted } O_2} = [0.076 g_{\text{depleted } O_2} / (\text{kWs})] \dot{Q}$$

The input data required to describe the above depleted oxygen generation rate are $PRODH = 1$ and $BETAH = 0.076$.

Note that in this example, detection does not occur as a result of a detectable product of combustion. Accordingly, it will not be necessary to enter input data which describe the generation of a detectable product.

Finally, it is assumed that Available Safe Egress Times in excess of 30 minutes are of no particular interest, and the fire conditions will not be modeled beyond this time.

Interactive Data Input:

WILL DATA BE ENTERED INTERACTIVELY (Y/N)?

ENTER: yes

PROGRAM WILL BE EXECUTED IN THE INTERACTIVE MODE.

INSTRUCTIONS

TO ENTER DATA: TYPE REQUESTED VALUE OR VALUES (MULTIPLE VALUES
SEPARATED BY A COMMA OR BLANK), THEN PRESS CARRIAGE RETURN.

ENTER A RUN TITLE, UP TO 80 CHARACTERS LONG.

ENTER: constant fire, q = 1320 kW

ENTER CODE NUMBER OF THE DESIRED FORM OF OUTPUT:

TYPE 1 FOR SUMMARY OUTPUT, 132 CHARACTERS PER LINE

2 FOR SUMMARY OUTPUT, 80 CHARACTERS PER LINE

3 FOR FULL OUTPUT, 132 CHARACTERS PER LINE

4 FOR FULL OUTPUT, 80 CHARACTERS PER LINE

ENTER: 2

SUMMARY OUTPUT, 80 CHARACTERS PER LINE HAS BEEN SELECTED.

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER: 1. LAMDA R,

2. LAMDA C,

3. EYELEVEL HEIGHT, IN FEET, AND

4. FIRE HEIGHT, IN FEET.

DO YOU NEED MORE INFORMATION (Y/N)?

ENTER: no

ENTER THE REQUESTED VALUES.

ENTER: .35, .6, 4., 0.0

LAMDA R = .35000

LAMDA C = .60000

EYELEVEL HEIGHT = 4.0000

FIRE HEIGHT = 0.0000

IS THIS CORRECT (Y/N)?

ENTER: yes

DATA WILL BE ENTERED IN THE FOLLOWING ORDER:

- | | |
|-----------------------|--------------------------------|
| I. DETECTION CRITERIA | IV. FIRE DATA |
| II. HAZARD CRITERIA | V. PRODUCTS OF COMBUSTION DATA |
| III. ROOM SIZES | |

I. DETECTION CRITERIA

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F (DETECTION).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO DETECTION BY RATE OF RISE.

ENTER: @eof

ENTER A RATE OF LAYER TEMPERATURE RISE, IN DEGREES F/MIN (DETECTION).

(TYPE 0.0 FOR INSTANTANEOUS DETECTION.)

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO DETECTION BY CONCENTRATION.

ENTER: 0.0

0.0000 (INSTANTANEOUS DETECTION)

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A RATE OF LAYER TEMPERATURE RISE, IN DEGREES F/MIN (DETECTION).

(TYPE 0.0 FOR INSTANTANEOUS DETECTION.)

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO DETECTION BY CONCENTRATION.

ENTER: @eof

ENTER A CONCENTRATION OF A PRODUCT OF COMBUSTION,

IN PRODUCT UNITS/GRAM OF BULK GAS (DETECTION).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD CRITERIA DATA INPUT.

ENTER: @eof

II. HAZARD CRITERIA

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F

(INTERFACE ABOVE SPECIFIED EYELEVEL) (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD

BY LAYER TEMPERATURE WHEN INTERFACE BELOW EYELEVEL.

ENTER: 361.4

361.40

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F

(INTERFACE ABOVE SPECIFIED EYELEVEL) (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD

BY LAYER TEMPERATURE WHEN INTERFACE BELOW EYELEVEL.

ENTER: @eof

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F

(INTERFACE BELOW SPECIFIED EYELEVEL) (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD BY POC CONCENTRATION.

ENTER: 240.0

240.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F

(INTERFACE BELOW SPECIFIED EYELEVEL) (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD BY POC CONCENTRATION.

ENTER: @eof

ENTER A CONCENTRATION OF A PRODUCT OF COMBUSTION,

IN PRODUCT UNITS/GRAM OF BULK GAS (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO ROOM SIZE DATA INPUT.

ENTER: 0.05

5.0000-02

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A CONCENTRATION OF A PRODUCT OF COMBUSTION,

IN PRODUCT UNITS/GRAM OF BULK GAS (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO ROOM SIZE DATA INPUT.

ENTER: @eof

III. ROOM SIZE DATA

ENTER A COMPARTMENT CEILING HEIGHT, IN FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO COMPARTMENT AREA INPUT.

ENTER: 10.0

10.000

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT CEILING HEIGHT, IN FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO COMPARTMENT AREA INPUT.

ENTER: @eof

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 11000.

11000.

IS THIS CORRECT (Y/N)?

ENTER: no

ENTER THE CORRECT VALUE(S).

ENTER: 10000.

10000.

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: @eof

IV. FIRE DATA

SELECT THE REPRESENTATIVE FORM OF FIRE ENERGY GENERATION.

TYPE 1 FOR AN EXPONENTIAL FIRE GROWTH CURVE.

2 FOR DIGITAL DATA INPUT.

ENTER: 2

DIGITAL DATA INPUT HAS BEEN SELECTED.

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER: 1. THE MAXIMUM TIME, IN SECONDS, FOR WHICH THE FIRE WILL BE MODELED,
AND

2. THE HEAT OF COMBUSTION, IN KJ/KG.

ENTER: 1800.0, 1.0

MAXIMUM TIME = 1800.0

HEAT OF COMBUSTION = 1.0000

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER THE INITIAL ENERGY GENERATION RATE.

ENTER: 1320.0

$$Q\emptyset = .1320+04$$

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER THE REST OF THE DIGITAL DATA POINTS ONE AT A TIME.

EACH DATA POINT SHOULD CONSIST OF A TIME, IN SECONDS,

AND A CORRESPONDING ENERGY GENERATION RATE.

WHEN ALL HAVE BEEN ENTERED, TYPE AN END OF FILE (UNIVAC: @EOF).

ENTER: 1800.0, 1320.0

ENTER: @eof

$$\text{TAUQ}(1) = 1800.0 \quad Q(1) = .1320+04$$

ARE THESE DATA POINTS CORRECT (Y/N)?

ENTER: yes

DO YOU WANT FIRE ENERGY GENERATION RATE DATA

PRESENTED IN NORMALIZED FORM, $Q(T)/Q\emptyset$ (Y/N)?

ENTER: no

V.1 DETECTABLE PRODUCT OF COMBUSTION DATA

SINCE THERE WERE NO DETECTABLE CONCENTRATIONS SPECIFIED,

DATA DESCRIBING THE GENERATION OF A DETECTABLE PRODUCT

OF COMBUSTION WILL NOT BE REQUIRED.

V.2 HAZARDOUS PRODUCT OF COMBUSTION DATA

SELECT THE REPRESENTATIVE FORM OF PRODUCT GENERATION RATE.

TYPE 1 FOR A METHOD USING A CONSTANT OF PROPORTIONALITY.

2 FOR DIGITAL DATA INPUT.

ENTER: 1

A METHOD USING A CONSTANT OF PROPORTIONALITY HAS BEEN SELECTED.

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER BETAH,

IN PRODUCT UNITS PER SEC PER KW OF FIRE GENERATION RATE.

PRODUCT GENERATION RATE = BETAH X ENERGY GENERATION RATE

ENTER: 0.076

7.6000-02

IS THIS CORRECT (Y/N)?

ENTER: yes

Batch Data Input:

The data required to solve the problem will now be shown in batch form. Each line of data represents either a computer punch card or a line of data typed at a computer terminal in batch mode. The extended form of output (132 characters/line) is desired so the write code has been changed to 3. The first card in a batch data group must contain the words "BATCH DATA".

1. General Data

BATCH DATA

Run title

CONSTANT FIRE, Q = 1320 kW

Write code

3

λ_r , λ_c , eyelevel, fire height

.35, .60, 4., 0.0

2. Detection Criteria

Layer temperature @EOF

Rate of temperature rise 0.0
@EOF

Concentration @EOF

3. Hazard Criteria

Temperature when interface above eyelevel 361.4
@EOF

Temperature when interface below eyelevel 240.0
@EOF

Concentration 0.05
@EOF

4. Room Characteristics

Height 10.0
@EOF

Area 10000.
@EOF

5. Fire Data: Energy Generation Rate

Fire type 2

Maximum time, heat of combustion 1800., 1.0

Initial energy generation rate	1320.
Data points	1800., 1320. @EOF
Normalized Output?	NO - NORMALIZED OUTPUT

6. Fire Data: Detectable Product of Combustion Generation Rate

7. Fire Data: Hazardous Product of Combustion Generation Rate

Product generation code	1
-------------------------	---

Beta, constant of proportionality	0.076
-----------------------------------	-------

Results:

The relevant portion of the computer output from the batch run is presented in Figure 2. These results indicate that for a fire with a constant energy generation rate equal to 1250 BTU/s (1320 kW) in a room with a 10 ft (3.05 m) high ceiling and an area of 10,000 ft² (929.0 m²), the available safe egress time, assuming immediate detection and alarm, is 191 seconds or about 3.2 minutes. The onset of hazardous conditions occurs when the upper layer temperature reaches 361.4°F (183.0°C). At this point, the smoke layer interface has reached a position 6.95 ft (2.12 m) above the floor, the concentration of the (unspecified) detectable product is zero, and the concentration of the hazardous product, $g_{\text{depleted } O_2} \text{ per } g_{\text{upper}}$ in the present example, is 0.03 (i.e., at the time of hazard, the mass fraction of oxygen in the upper layer is $0.23 - 0.03 = 0.20$, which is still large enough for vitiation effects to be considered as negligible). Notice in Figure 2, that at the time of detection, which immediately follows ignition, the concentration of depleted oxygen in the newly forming upper layer is already nonzero. These upper layer gases have, in fact, come from the fire-generated plume gases, which are always a source of depleted oxygen.

Using the results of this run, it is possible to determine the available safe egress time if the fire is detected at some nonzero time subsequent to ignition. For example, if detection occurred 60 seconds after ignition of the fire, the available safe egress time would be $(191-60)$ seconds = 131 seconds or about 2.2 minutes.

3.2 Example 2 - A Semi-Universal Growing Fire Hazard

In this example the hazard which develops from a semi-universal growing fire will be studied. The results of applying several different methods of detection will be evaluated.

The semi-universal fire is the result of a fit of data from free burn tests on a variety of different types of commodities to a three-segment, multi-exponential fire growth curve [2]. The fire is initiated from a 10 kW (9.5 BTU/s) ignition source. It grows exponentially at a rate characteristic of a fire initiated in a polyurethane mattress with bedding [8]. This early growth rate may also be appropriate for use in characterizing the early growth of fires in upholstered polyurethane cushioning and large assemblies of commodities stacked on pallets. The fire growth rate beyond 400 kW (379 BTU/s), described in two segments, is similar to that observed for fires initiated in a variety of different types of commodities stacked on pallets [8]. These latter portions of the semi-universal fire would be representative of fires in large mercantile, storage, and/or business occupancies. The equations which characterize this semi-universal fire and the associated input data have been described earlier in Section 2.6 under the subheading: Multi-exponential curve.

The fire will be assumed to occur in an occupied $5,000 \text{ ft}^2$ (465 m^2) nominal 20 ft (6.1 m) high ceiling auditorium outfitted with polyurethane cushion seats. Since life safety considerations are likely to be key, the auditorium is assumed to be occupied and detection by the occupants is assumed to be immediate (rate-of-rise at detection is $0.^\circ\text{F}/\text{min}$).

For illustrative purposes, cases of detection when the average upper layer reaches 135°F (54°C), and detection when the rate of upper layer temperature rise reaches $15^\circ\text{F}/\text{min}$ ($8.33^\circ\text{C}/\text{min}$) will also be examined. These cases may be useful in evaluating the use of thermal sensor detectors for providing property protection of the auditorium during unoccupied periods of time.

If the smoke layer interface is located more than 3 ft (0.91 m) from the floor, hazardous conditions will be assumed to occur when and if the average upper layer temperature reaches 361°F (183°C). Once the interface reaches the 3 ft (0.91 m) elevation, the onset of hazardous conditions will be assumed to occur if the average upper layer temperature reaches 240°F (115.6°C) or if the concentration of CO exceeds 2500 parts per million (ppm) (0.0025 grams of CO per gram of upper layer mixture), whichever comes first. The CO generation rate will be taken as proportional to the energy release rate through a constant of proportionality of $0.007 \text{ g}_{\text{CO}}/(\text{skW})$. This latter value can be deduced from [9] for smoldering combustion in polyurethane. Flaming combustion would likely result in a smaller constant of proportionality.

For the moderate span-to-height aspect ratio of the present auditorium [assume the span to be approximately $(5000 \text{ ft}^2)^{1/2}$ 70 ft (22 m), for a span-to-height ratio of approximately 3.5], it is reasonable to assume that 75 percent of the total energy release is instantaneously transferred to the surfaces

of the auditorium and its contents. As in the previous example, the instantaneous radiation loss from the combustion zone is assumed to be 35 percent of the energy release.

The ASET's for the above scenario will be determined under the condition that the fire is located 2 ft (0.6 m) above the floor.

If hazardous conditions are not attained by 20 minutes after ignition, then the analysis will be terminated.

Interactive Data Input:

WILL DATA BE ENTERED INTERACTIVELY (Y/N)?

ENTER: yes

PROGRAM WILL BE EXECUTED IN THE INTERACTIVE MODE.

INSTRUCTIONS

TO ENTER DATA: TYPE REQUESTED VALUE OR VALUES (MULTIPLE VALUES SEPARATED BY A COMMA OR BLANK), THEN PRESS CARRIAGE RETURN.

ENTER A RUN TITLE, UP TO 80 CHARACTERS LONG.

ENTER: multi-exponential fire growth

ENTER CODE NUMBER OF THE DESIRED FORM OF OUTPUT:

TYPE 1 FOR SUMMARY OUTPUT, 132 CHARACTERS PER LINE

2 FOR SUMMARY OUTPUT, 80 CHARACTERS PER LINE

3 FOR FULL OUTPUT, 132 CHARACTERS PER LINE

4 FOR FULL OUTPUT, 80 CHARACTERS PER LINE

ENTER: 2

SUMMARY OUTPUT, 80 CHARACTERS PER LINE HAS BEEN SELECTED.

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER: 1. LAMDA R,

2. LAMDA C,

3. EYELEVEL HEIGHT, IN FEET, AND

4. FIRE HEIGHT, IN FEET.

DO YOU NEED MORE INFORMATION (Y/N)?

ENTER: no

ENTER THE REQUESTED VALUES.

ENTER: .35, .75, 3., 2.

LAMDA R = .35000

LAMDA C = .75000

EYELEVEL HEIGHT = 3.0000

FIRE HEIGHT = 2.0000

IS THIS CORRECT (Y/N)?

ENTER: yes

DATA WILL BE ENTERED IN THE FOLLOWING ORDER:

I. DETECTION CRITERIA

IV. FIRE DATA

II. HAZARD CRITERIA

V. PRODUCTS OF COMBUSTION DATA

III. ROOM SIZES

I. DETECTION CRITERIA

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F (DETECTION).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO DETECTION BY RATE OF RISE.

ENTER: 135.0

135.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F (DETECTION).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO DETECTION BY RATE OF RISE.

ENTER: @eof

ENTER A RATE OF LAYER TEMPERATURE RISE, IN DEGREES F/MIN (DETECTION).

(TYPE 0.0 FOR INSTANTANEOUS DETECTION.)

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO DETECTION BY CONCENTRATION.

ENTER: 0.0

0.0000 (INSTANTANEOUS DETECTION)

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A RATE OF LAYER TEMPERATURE RISE, IN DEGREES F/MIN (DETECTION).

(TYPE 0.0 FOR INSTANTANEOUS DETECTION.)

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO DETECTION BY CONCENTRATION.

ENTER: 15.0

15.000

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A RATE OF LAYER TEMPERATURE RISE, IN DEGREES F/MIN (DETECTION).

(TYPE 0.0 FOR INSTANTANEOUS DETECTION.)

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO DETECTION BY CONCENTRATION.

ENTER: @eof

ENTER A CONCENTRATION OF A PRODUCT OF COMBUSTION,

IN PRODUCT UNITS/GRAM OF BULK GAS (DETECTION).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD CRITERIA DATA INPUT.

ENTER: @eof

II. HAZARD CRITERIA

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F,

(INTERFACE ABOVE SPECIFIED EYELEVEL) (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD

BY LAYER TEMPERATURE WHEN INTERFACE BELOW EYELEVEL.

ENTER: 361.4

361.40

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F

(INTERFACE ABOVE SPECIFIED EYELEVEL) (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD

BY LAYER TEMPERATURE WHEN INTERFACE BELOW EYELEVEL.

ENTER: @eof

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F

(INTERFACE BELOW SPECIFIED EYELEVEL) (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD BY POC CONCENTRATION.

ENTER: 240.0

240.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F

(INTERFACE BELOW SPECIFIED EYELEVEL) (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD BY POC CONCENTRATION.

ENTER: @eof

ENTER A CONCENTRATION OF A PRODUCT OF COMBUSTION,

IN PRODUCT UNITS/GRAM OF BULK GAS (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO ROOM SIZE DATA INPUT.

ENTER: 0.0025

2.5000-03

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A CONCENTRATION OF A PRODUCT OF COMBUSTION,

IN PRODUCT UNITS/GRAM OF BULK GAS (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO ROOM SIZE DATA INPUT.

ENTER: @eof

III. ROOM SIZE DATA

ENTER A COMPARTMENT CEILING HEIGHT, IN FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO COMPARTMENT AREA INPUT.

ENTER: 20.0

20.000

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT CEILING HEIGHT, IN FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO COMPARTMENT AREA INPUT.

ENTER: @eof

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 5000.0

5000.0

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: @eof

IV. FIRE DATA

SELECT THE REPRESENTATIVE FORM OF FIRE ENERGY GENERATION.

TYPE 1 FOR AN EXPONENTIAL FIRE GROWTH CURVE.

2 FOR DIGITAL DATA INPUT.

ENTER: 1

AN EXPONENTIAL FIRE GROWTH CURVE HAS BEEN SELECTED.

IS THIS CORRECT (Y/N)?

ENTER: yes

GENERAL FORM: $Q=Q_1 \text{ EXP}(\text{ALPHA}(T-T_1))$

ENTER THE MAXIMUM TIME, IN SECONDS, FOR WHICH THE FIRE WILL BE MODELED.

ENTER: 1200.0

1200.0

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER: 1. THE ENERGY GENERATION RATE (Q_1), IN KILOWATTS,

AT THE BEGINNING OF EACH TIME SEGMENT, AND

2. THE ENERGY GENERATION RATE EXPONENTIAL FACTOR (ALPHA),

IN UNITS OF 1/SECOND, FOR THAT TIME SEGMENT.

ENTER ONE PAIR FOR EACH TIME SEGMENT IN THE CURVE.

ENTER THEM ONE AT A TIME.

WHEN ALL HAVE BEEN ENTERED, TYPE AN END OF FILE (UNIVAC: @EOF).

ENTER: 10.0, 0.025

ENTER: 400.0, 0.010

ENTER: 3000.0, 0.005

ENTER: @eof

1. $Q = 10.0 \text{ EXP}(.025(T-T_1))$

2. $Q = 400.0 \text{ EXP}(.010(T-T_1))$

3. $Q = 3000.0 \text{ EXP}(.005(T-T_1))$

ARE THE EQUATIONS CORRECT (Y/N)?

ENTER: yes

DO YOU WANT FIRE ENERGY GENERATION RATE DATA

PRESENTED IN NORMALIZED FORM, $Q(t)/Q(1)$ (Y/N)?

ENTER: yes

V.1. DETECTABLE PRODUCT OF COMBUSTION DATA

SINCE THERE WERE NO DETECTABLE CONCENTRATIONS SPECIFIED,
DATA DESCRIBING THE GENERATION OF A DETECTABLE PRODUCT
OF COMBUSTION WILL NOT BE REQUIRED.

V.2. HAZARDOUS PRODUCT OF COMBUSTION DATA

SELECT THE REPRESENTATIVE FORM OF PRODUCT GENERATION RATE.

TYPE 1 FOR A METHOD USING A CONSTANT OF PROPORTIONALITY.

2 FOR DIGITAL DATA INPUT.

ENTER: 1

A METHOD USING A CONSTANT OF PROPORTIONALITY HAS BEEN SELECTED.

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER BETAH,

IN PRODUCT UNITS PER SEC PER KW OF FIRE ENERGY GENERATION RATE.

PRODUCT GENERATION RATE = BETAH X ENERGY GENERATION RATE.

ENTER: 0.007

7.0000-03

IS THIS CORRECT (Y/N)?

ENTER: yes

Batch Data Input:

The data required to solve the problem will now be shown in batch form. Each line of data represents either a computer punch card or a line of data typed at a computer terminal in batch mode. The extended form of output (132 characters/line) is desired so the write code value will be changed to 3. The first card in a batch data group must contain the words "BATCH DATA".

1. General Data

	BATCH DATA
Run title	MULTI-EXPONENTIAL FIRE GROWTH
Write code	3
λ_r , λ_c , eyelevel, fire height	.35, .75, 3., 2.0

2. Detection Criteria

Layer temperature	135.0
	@EOF
Rate of temperature rise	0.0
	15.0
	@EOF
Concentration	@EOF

3. Hazard Criteria

Temperature when interface above eyelevel	361.4
	@EOF
Temperature when interface below eyelevel	240.0
	@EOF
Concentration	0.0025
	@EOF

4.	Room Characteristics	
	Height	20.0
		@EOF
	Area	5000.0
		@EOF
5.	Fire Data: Energy Generation Rate	
	Fire type	1
	Maximum time	1200.0
	Energy generation rates, exponential factors	10.0, 0.025 400.0, 0.010 3000.0, 0.005
		@EOF
	Normalized Output?	YES - NORMALIZED OUTPUT
6.	Fire Data: Detectable Product of Combustion Generation Rate	
7.	Fire Data: Hazardous Product of Combustion Generation Rate	
	Product generation code	1
	Beta, constant of proportionality	0.007

Results:

The immediate detection (rate of rise is 0.°F/min) portion of the computer output from the batch run is presented in Figure 3. These results indicate that for a fire 2 ft (0.6 m) above the floor of a room of ceiling height 20 ft (6.1 m)

and area 5000 ft^2 (465 m^2), whose rate-of-energy release is reasonably described by the semi-universal fire described earlier, the onset of hazardous conditions occurs approximately 523 seconds or 8.7 minutes after ignition. Thus, for a case of immediate fire detection and successful alarm, the ASET is also 8.7 minutes.

At the time of onset of hazardous conditions the average upper layer temperature is 355.5°F (179.7°C), the smoke layer interface is 3 ft (0.91 m) from the floor, and the average concentration of CO in the upper layer is 0.004 grams of CO per gram of upper layer mixture. Hazardous conditions are initiated when the interface reaches the specified 3 ft (0.91 m) height of eyelevel on account of the fact that the upper layer is of untenably high temperature (vis a vis potential internal and/or external burns from ingestion and/or direct skin contact) at that time.

If fire detection and alarm is not immediate, but occurs when the upper layer temperature reaches 135°F (57.2°C), then the time of detection is 318 seconds and the ASET is reduced to 205 seconds. If detection occurs when the upper layer rate-of-temperature-rise reaches $15^\circ\text{F}/\text{min}$ ($8.33^\circ\text{C}/\text{min}$), then the time of detection is 219 seconds and the ASET is 304 seconds.

3.3 Example 3 - Flashover Potential Due to a Fire in an Assembly of Bedding Combustibles

In this last example the potential for room flashover due to a fire confined to a wastepaper basket-(polyurethane) single mattress-bedding fuel assembly will be evaluated. An estimate of the energy release rate during the free burn

of such a grouping of combustibles from ignition and on through fuel depletion has been obtained from data of Babrauskas [5], and is plotted in Figure 3 of [2]. From ignition to $t = 900$ seconds this energy release rate history can be approximated by the following ten pair of points with linear interpolation between them:

Time	Energy Release Rate
(s)	(kW)
0	2.
70	36.
140	1.
210	27.
290	200.
390	1200.
525	290.
650	106.
775	55.
900	38.

While a survey of literature by Peacock [10] indicated that an upper layer temperature criterion for flashover is typically taken to be in the range of 1020-1420°F (550-770°C), the present model is not formulated in a manner as to yield reliable results at temperatures beyond the approximate range 660-840°F (350-450°C). Accordingly, for the present evaluations a criterion for flashover potential will be conservatively set at 750°F (400°C).

The fire described by the above energy release rate history will be "placed" in rooms of ceiling height 8 and 12 ft (2.4 and 3.7 m) and areas ranging from 100-10000 ft² (9.3 - 929 m²). As in Example 2, ALAMC and ALAMR will be taken as 0.70 and 0.35, respectively. The time of detection will be taken to be the time of ignition. Onset of hazard will be interpreted as occurring when the potential for flashover exists, i.e., when the upper layer temperature reaches 750°F (400°C), no matter what the elevation of the interface. Under these conditions, the ASET to be computed is to be interpreted as the time from ignition to the time of potential flashover.

In a manner similar to that of Example 1, depleted oxygen will be assigned the role of hazardous combustion product, where its hazardous concentration will be taken as $0.09 \text{ g}_{\text{depleted } \text{O}_2} \text{ per } \text{g}_{\text{upper}}$ (corresponding to a total oxygen concentration of $0.23 - 0.09 = 0.14 \text{ g}_{\text{O}_2} \text{ per } \text{g}_{\text{upper}}$). Also, eyelevel as well as fire elevation will be taken as 2 ft (0.6 m). If the interface is below the 2 ft (0.6 m) fire elevation, and the oxygen concentration is below $0.12\text{--}0.14 \text{ g}_{\text{O}_2} \text{ per } \text{g}_{\text{upper}}$, then the fire will be submerged in a vitiated environment whose oxygen level may not support continued flaming combustion. By using the hazardous product criterion in the manner suggested, the calculation would be appropriately terminated under such circumstances, and the event would be clearly identified as onset of extreme vitiation. Indeed, even if extreme vitiation does not occur prior to potential flashover, the depleted oxygen concentration at the time of flashover would be an interesting output of the calculation.

Interactive Data Input:

WILL DATA BE ENTERED INTERACTIVELY (Y/N)?

ENTER: yes

PROGRAM WILL BE EXECUTED IN THE INTERACTIVE MODE.

INSTRUCTIONS

TO ENTER DATA: TYPE REQUESTED VALUE OR VALUES (MULTIPLE VALUES SEPARATED BY A COMMA OR BLANK), THEN PRESS CARRIAGE RETURN.

ENTER A RUN TITLE, UP TO 80 CHARACTERS LONG.

ENTER: flashover potential

ENTER CODE NUMBER OF THE DESIRED FORM OF OUTPUT:

TYPE 1 FOR SUMMARY OUTPUT, 132 CHARACTERS PER LINE

2 FOR SUMMARY OUTPUT, 80 CHARACTERS PER LINE

3 FOR FULL OUTPUT, 132 CHARACTERS PER LINE

4 FOR FULL OUTPUT, 80 CHARACTERS PER LINE

ENTER: 2

SUMMARY OUTPUT, 80 CHARACTERS PER LINE HAS BEEN SELECTED.

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER: 1. LAMDA R,

2. LAMDA C,

3. EYELEVEL HEIGHT, IN FEET, AND

4. FIRE HEIGHT, IN FEET.

DO YOU NEED MORE INFORMATION (Y/N)?

ENTER: no

ENTER THE REQUESTED VALUES

ENTER: .35, .70, 2., 2.

LAMDA R = .35000

LAMDA C = .70000

EYELEVEL HEIGHT = 2.0000

FIRE HEIGHT = 2.0000

IS THIS CORRECT (Y/N)?

ENTER: yes

DATA WILL BE ENTERED IN THE FOLLOWING ORDER:

- | | |
|-----------------------|--------------------------------|
| I. DETECTION CRITERIA | IV. FIRE DATA |
| II. HAZARD CRITERIA | V. PRODUCTS OF COMBUSTION DATA |
| III. ROOM SIZES | |

I. DETECTION CRITERIA

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F (DETECTION).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO DETECTION BY RATE OF RISE.

ENTER: @eof

ENTER A RATE OF LAYER TEMPERATURE RISE, IN DEGREES F/MIN (DETECTION).

(TYPE 0.0 FOR INSTANTANEOUS DETECTION.)

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO DETECTION BY CONCENTRATION.

ENTER: 0.0

0.0000 (INSTANTANEOUS DETECTION)

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A RATE OF LAYER TEMPERATURE RISE, IN DEGREES F/MIN (DETECTION).

(TYPE 0.0 FOR INSTANTANEOUS DETECTION.)

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO DETECTION BY CONCENTRATION.

ENTER: @eof

ENTER A CONCENTRATION OF A PRODUCT OF COMBUSTION,

IN PRODUCT UNITS/GRAM OF BULK GAS DETECTION.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD CRITERIA DATA INPUT.

ENTER: @eof

II. HAZARD CRITERIA

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F

(INTERFACE ABOVE SPECIFIED EYELEVEL) (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD

BY LAYER TEMPERATURE WHEN INTERFACE BELOW EYELEVEL.

ENTER: 750.0

750.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F
(INTERFACE ABOVE SPECIFIED EYELEVEL) (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD
BY LAYER TEMPERATURE WHEN INTERFACE BELOW EYELEVEL.

ENTER: @eof

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F
(INTERFACE BELOW SPECIFIED EYELEVEL) (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD BY POC CONCENTRATION.

ENTER: 750.0

750.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F
(INTERFACE BELOW SPECIFIED EYELEVEL) (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO HAZARD BY POC CONCENTRATION.

ENTER: @eof

ENTER A CONCENTRATION OF A PRODUCT OF COMBUSTION,
IN PRODUCT UNITS/GRAM OF BULK GAS (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO ROOM SIZE DATA INPUT.

ENTER: 0.09

9.0000-02

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A CONCENTRATION OF A PRODUCT OF COMBUSTION,
IN PRODUCT UNITS/GRAM OF BULK GAS (HAZARD).

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO ROOM SIZE DATA INPUT.

ENTER: @eof

III. ROOM SIZE DATA

ENTER A COMPARTMENT CEILING HEIGHT, IN FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO COMPARTMENT AREA INPUT.

ENTER: 8.0

8.0000

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT CEILING HEIGHT, IN FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO COMPARTMENT AREA INPUT.

ENTER: 12.0

12.000

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT CEILING HEIGHT, IN FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO COMPARTMENT AREA INPUT.

ENTER: @eof

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT

ENTER: 100.0

100.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 120.0

120.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 200.0

200.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 250.0

250.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 300.0

300.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 400.0

400.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 500.0

500.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 600.0

600.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 800.0

800.00

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 1000.0

1000.0

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 1200.0

1200.0

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 2000.0

2000.0

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 3000.0

3000.0

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 4000.0

4000.0

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 5000.0

5000.0

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 6000.0

6000.0

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 8000.0

8000.0

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: 10000.0

10000.

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.

TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.

ENTER: @eof

IV. FIRE DATA

SELECT THE REPRESENTATIVE FORM OF FIRE ENERGY GENERATION.

TYPE 1 FOR AN EXPONENTIAL FIRE GROWTH CURVE.

2 FOR DIGITAL DATA INPUT.

ENTER: 2

DIGITAL DATA INPUT HAS BEEN SELECTED.

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER: 1. THE MAXIMUM TIME, IN SECONDS, FOR WHICH THE FIRE WILL BE MODELED,
AND

2. THE HEAT OF COMBUSTION, IN KJ/KG.

ENTER: 900.0, 1.0

MAXIMUM TIME = 900.0

HEAT OF COMBUSTION = 1.000

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER THE INITIAL ENERGY GENERATION RATE.

ENTER: 2.0

$Q\phi = .2000+01$

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER THE REST OF THE DIGITAL DATA POINTS ONE AT A TIME.

EACH DATA POINT SHOULD CONSIST OF A TIME, IN SECONDS, AND

A CORRESPONDING ENERGY GENERATION RATE.

WHEN ALL HAVE BEEN ENTERED, TYPE AN END OF FILE (UNIVAC: @EOF).

ENTER: 70., 36.

ENTER: 140., 1.4

ENTER: 210., 27.

ENTER: 290., 200.

ENTER: 390., 1200.

ENTER: 525., 290.

ENTER: 650., 106.

ENTER: 775., 55.

ENTER: 900., 38.

ENTER: @eof

TAUQ(1) = 70.0	Q(1) = .3600+02
TAUQ(2) = 140.0	Q(2) = .1400+01
TAUQ(3) = 210.0	Q(3) = .2700+02
TAUQ(4) = 290.0	Q(4) = .2000+03
TAUQ(5) = 390.0	Q(5) = .1200+04
TAUQ(6) = 525.0	Q(6) = .2900+03
TAUQ(7) = 650.0	Q(7) = .1060+03
TAUQ(8) = 775.0	Q(8) = .5500+02
TAUQ(9) = 900.0	Q(9) = .3800+02

ARE THESE DATA POINTS CORRECT (Y/N)?

ENTER: yes

DO YOU WANT FIRE ENERGY GENERATION RATE DATA

PRESENTED IN NORMALIZED FORM, $Q(T)/Q\phi$ (Y/N)?

ENTER: no

V.1. DETECTABLE PRODUCT OF COMBUSTION DATA

SINCE THERE WERE NO DETECTABLE CONCENTRATIONS SPECIFIED,
DATA DESCRIBING THE GENERATION OF A DETECTABLE PRODUCT
OF COMBUSTION WILL NOT BE REQUIRED.

V.2. HAZARDOUS PRODUCT OF COMBUSTION DATA

SELECT THE REPRESENTATIVE FORM OF PRODUCT GENERATION RATE.
TYPE 1 FOR A METHOD USING A CONSTANT OF PROPORTIONALITY.

2 FOR DIGITAL DATA INPUT.

ENTER: 1

A METHOD USING A CONSTANT OF PROPORTIONALITY HAS BEEN SELECTED.

IS THIS CORRECT (Y/N)?

ENTER: yes

ENTER BETAH,

IN PRODUCT UNITS PER SEC PER KW OF FIRE ENERGY GENERATION RATE.

PRODUCT GENERATION RATE = BETAH X ENERGY GENERATION RATE

ENTER: 0.076

7.6000-02

IS THIS CORRECT (Y/N)?

ENTER: yes

Batch Data Input:

The data required to solve the problem will now be shown in batch form. Each line of data represents either a computer punch card or a line of data typed at a computer terminal in batch mode. The extended form of output is not desired in this example, so the write code value will be 1. The first card in a batch data group should contain the words "BATCH DATA".

1. General Data

	BATCH DATA
Run title	FLASHOVER POTENTIAL
Write code	1
λ_r , λ_c , eyelevel, fire height	.35, .70, 2., 2.

2. Detection Criteria

Layer temperature	@EOF
Rate of temperature rise	0.0
	@EOF
Concentration	@EOF

3. Hazard Criteria

Temperature when interface above eyelevel	750.0
	@EOF
Temperature when interface below eyelevel	750.0
	@EOF
Concentration	0.09
	@EOF

4. Room Characteristics

Height	8.0
	12.0
	@EOF
Area	100.
	120.
	200.
	250.
	300.
	400.
	500.
	600.
	800.
	1000.
	1200.
	2000.
	3000.
	4000.
	5000.

6000.
8000.
10000.
@EOF

5. Fire Data: Energy Generation Rate

Fire type 2

Maximum time, heat of combustion 900., 1.0

Initial energy generation rate 2.0

Data points 70., 36.
140., 1.4
210., 27.
290., 200.
390., 1200.
525., 290.
650., 106.
775., 55.
900., 38.
@EOF

Normalized Output? NO - NORMALIZED OUTPUT

6. Fire Data: Detectable Product of Combustion Generation Rate

7. Fire Data: Hazardous Product of Combustion Generation Rate

Product generation code 1

Beta, constant of proportionality 0.076

Results:

The relevant portion of the computer output from the batch run is presented in Figure 4. The results from this have been plotted in Figure 5. There, the time to reach potential flashover [750°F (400°C)] is plotted against room area for the two room heights considered. From this figure it is possible to reach the following conclusions: For a fire confined to the subject fuel assembly:

- (a) Flashover is not likely to take place in 8 ft (2.4 m) high rooms of area larger than 2000 ft² (186 m²) or in 12 ft (3.7 m) high rooms of area larger than 800 ft² (74 m²); for rooms of smaller area the times of potential flashover can be identified from the plots.
- (b) At the time of potential flashover the oxygen concentration of the environment which surrounds the combustion zone is always large enough (approximately 0.14) so that extinction on account of oxygen vitiation may still not have occurred.

4. FUTURE EFFORTS

As indicated by the example calculations of the last section, the ASET computer program should prove useful as a tool for providing practical estimates of enclosure fire environments, in general, and of Available Safe Egress Times, in particular.

The present ASET computer program is intended to represent an initial, rather than a final, stage of development. Indeed, by measure of the numbers and general interest of users which are attracted to it, the more successful this computer program proves to be, the more likely it is that advanced versions will be developed. In this regard, future ASET computer programs would incorporate more detailed and more extensive mathematical simulations of the essential features of enclosure fire phenomena. Advanced computer programs would also provide a capability for invoking more sophisticated criteria for detection and onset of hazard, criteria which were not constrained to one, or even a few discrete environment descriptor end-points. Finally, it is evident that future ASET programs could be significantly improved in terms of the method of inputting data and of retrieving computer generated results. The potential for adding these last types of improvements is clearly constrained only by decisions on priorities in distributing available resources.

In short, the future of the ASET computer program concept is strongly dependent on the nature of user feedback, which is heartily encouraged.

5. REFERENCES

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APPENDIX A: PROGRAM DESCRIPTION

General Comments

This computer program was written in ASCII Fortran (FTN) for the Univac 1100/80 computer located at the National Bureau of Standards. This program may also be used on any computer with an ANSI FORTRAN compiler. It contains about 2300 source program statements and can be run on almost any digital computer of adequate capacity. The program does not require any UNIVAC or other computer specific subroutines. Output may be in either 80 characters per line or 132 characters per line format.

A program listing is provided in Appendix B. The main program and subroutines are described below.

MAIN Program

The MAIN program reads the required input data and governs the overall execution of the program. Statements in this part of the program allow it to be run in either the interactive or batch mode. When in the interactive mode, error checks have been provided to ensure that the data is entered correctly.

A "COMPUTED GO TO" statement in this part of the program allows the user to select any one of three representative forms of fire energy generation rate. Only two models have been provided; the user may add a third, if desired. In the first fire simulation model the energy generation rate is simulated by joined, exponentially growing curve segments. The number of

segments and the specific equations for each segment are deduced from user-supplied input data. In the second fire simulation model the energy generation rate is simulated by joined, linear curve segments, where, again, the number of segments and the linear interpolation between segment endpoints are deduced from user-supplied data.

Another "COMPUTED GO TO" statement allows the user to describe the generation of a detectable product of combustion in one of three ways. One method uses a constant of proportionality to relate the products of combustion generation rate to the energy generation rate. Another method uses linear interpolation between user supplied data points to describe the generation rate history of some detectable product of combustion. Again, the user may add some other model of detectable product of combustion generation, if desired.

A third "COMPUTED GO TO" statement allows the user to choose one of three ways to describe the generation of a hazardous product of combustion. The choices are the same as those used to describe the generation of a detectable product of combustion.

For each detection mode, the room sizes are evaluated for hazard occurrence. A maximum of twenty room ceiling heights and thirty compartment areas may be specified for each run of the program. As many as ten values may be used for each detection or hazard mode. Any combination of detection modes, hazard criteria, and room sizes may be used. It is not necessary to use all detection modes, hazard criteria, and room sizes, but at least one of each must be specified.

EXFIRE Subroutine

If the multi-exponential growth option is selected in MAIN, then this routine which is called one time, takes the input data and computes the initial times for each of the exponentially growing curve segments of the energy generation rate curve. In particular, the curve segments satisfy $\dot{Q} = \dot{Q}_i \exp[K_{i+1}(t-t_i)]$ for $i \geq 1$, and this routine finds all t_i from user-supplied $\dot{Q}_i$ and K_{i+1} . Having done this, the routine then provides a printout which explicitly describes the multi-exponential growth algorithm ultimately used to compute $\dot{Q}$.

FUNQ Subroutine

This subroutine calculates the energy generation rate at any given time. This routine is referenced by the SUBAINT and SUBF subroutines. It is currently divided into two parts. If the user wishes to develop another model of energy generation, then a third part may be added to this subroutine.

The first part of this subroutine uses the multi-exponential fire growth curve to compute energy generation rates. The other part computes energy generation rates using linear interpolation between digital data points.

FUNPRD Subroutine

This routine calculates the generation rate of some detectable product of combustion at any given time. This subroutine has also been divided into two parts. A third model of the generation of a detectable product of

combustion may be added by the user.

One part of FUNPRD uses a constant of proportionality, relating product of combustion generation rate to energy generation rate, to calculate detectable product of combustion generation rates. The other uses linear interpolation between digital data points to compute the detectable product of combustion generation rates.

FUNPRH Subroutine

This routine calculates the generation rate of some hazardous product of combustion at any given time. It is exactly the same as the FUNPRD subroutine.

SUBAINT Subroutine

This routine sets up the numerical integration necessary for obtaining the smoke layer interface position as it drops from the ceiling. It also sets up the integrations required to compute the history of the average upper layer temperature, detectable product of combustion concentration, and hazardous product of combustion concentration. The integrations are done in specified time intervals. Results from these integrations are checked against detection and hazard criteria to determine when detection and hazard occur. If detection or hazard occurs within a time interval, linear interpolation is used to obtain the time and fire environment characteristics at detection or hazard.

Finally, this subroutine will print the times of detection and hazard, the fire environment characteristics at detection and hazard, and the safe available egress time. If desired, it will print a history of these characteristics as the fire grows.

INTGR Subroutine

This subroutine is called by the SUBAINT subroutine to integrate the differential equations describing the smoke layer interface elevation, average upper layer temperature, detectable product of combustion concentration, and hazardous product of combustion concentration over a given time step size. It will segment the specified step size as necessary to obtain specified accuracy in the integration. If convergence has not been obtained after the original step size has been subdivided by a factor of 100, an error message is printed, the integration is terminated, and program execution continues with the next fire scenario.

SUBF Subroutine

This routine contains the differential equations which describe the development of the smoke layer interface elevation, the average upper layer temperature, the concentration of a detectable product of combustion, and the concentration of a hazardous product of combustion. It is required by the INTGR subroutine.

This subroutine has been divided into four parts. Each part consists of the four equations in forms appropriate for use during a certain time period. All but the first of these periods have been defined in terms of the location of the smoke layer interface. "IF" statements are used to determine which set of equations is appropriate at any given time.

The first part of this subroutine handles the special case at time equal to 0 when the fire is initiated. After the fire has been ignited and until such time as the smoke layer interface reaches the height of the fire, the general forms of the equations are used to determine interface elevation, layer temperature, and combustion product concentrations. Once the smoke layer interface reaches the height of the fire, the plume entrainment part of each equation may be eliminated. A third set of equations has been provided to handle this condition. When the smoke layer interface reaches the floor, the last set of equations is used.

INPUT Subroutine

When in the interactive mode, this subroutine is called by the MAIN program. It asks the user to confirm input values. If the value is incorrect, it solicits a new value. This routine is used to check almost all input values. It does not check the digital data input or some other values checked by the MAIN program.

INPUT2 Subroutine

When in the interactive mode, this subroutine is called by the MAIN program. It asks the user to confirm input values. If the value is incorrect, it solicits a new value. This routine is used to check the digital data point input (fire and product of combustion).

MAIN PROGRAM

```

C*****
C*****
C*
C*      CALCULATING AVAILABLE SAFE EGRESS TIME (ASET)
C*
C*****
C*****
C*
C*      WRITTEN BY LEONARD Y. COOPER AND
C*      DAVID W. STROUP
C*
C*      CENTER FOR FIRE RESEARCH
C*      NATIONAL ENGINEERING LABORATORY
C*      NATIONAL BUREAU OF STANDARDS
C*      U.S. DEPARTMENT OF COMMERCE
C*      WASHINGTON, D.C. 20234
C*
C*****
C*
C*      PROGRAM DOCUMENTATION:
C*
C*      NBSIR 82-2578
C*      CALCULATING AVAILABLE SAFE EGRESS TIME (ASET) -
C*      A COMPUTER PROGRAM AND USER'S GUIDE
C*
C*****
C*
C*      REVISED  SEPTEMBER 13, 1982
C*
C*****
C*****
C
C THIS IS EGRESS*ASET.MAIN.  IT REQUIRES EGRESS*ASET.EXFIRE
C AND EGRESS*ASET.SUBAINT
C
C*****
C
C      NOTATION
C
C*****
C AKAP(N) ENERGY GENERATION RATE EXPONENTIAL FACTOR IN THE NTH TIME
C SEGMENT. READ IN AND USED TO CHARACTERIZE THE MULTI-EXPONEN-
C TIAL ENERGY GENERATION RATE HISTORY.
C ALAMC THE FRACTION OF ENERGY GENERATION RATE INSTANTANEOUSLY LOST TO
C THE BOUNDING SURFACES OF THE ROOM AND ITS CONTENTS.
C ALAMR THE FRACTION OF ENERGY GENERATION RATE INSTANTANEOUSLY LOST BY
C RADIATION FROM THE COMBUSTION ZONE AND THE PLUME.
C AHF ARGUMENT - HF(K)
C ASF ARGUMENT - SF(M)
C ASM ARGUMENT - SM(M)
C BETAD CONSTANT OF PROPORTIONALITY BETWEEN DETECTABLE PRODUCT
C GENERATION RATE AND ENERGY GENERATION RATE.
C SPECIFICALLY DEFINED AS:
C
C      PRODUCT GENERATION RATE = BETAD * ENERGY GENERATION RATE
C

```


MAIN PROGRAM

```

C      OR
C
C      (PRODUCT GENERATION RATE / PRD0) = (BETAD * Q0/PRD0)
C      *(ENERGY GENERATION RATE / Q0)
C
C      USED WHEN PRODD=1.
C      READ IN DIMENSIONS OF PRODUCT UNITS/(SEC*KW).
C BETAH  CONSTANT OF PROPORTIONALITY BETWEEN HAZARDOUS PRODUCT
C      GENERATION RATE AND ENERGY GENERATION RATE.
C      SPECIFICALLY DEFINED AS:
C
C      PRODUCT GENERATION RATE = BETAH * ENERGY GENERATION RATE
C
C      OR
C
C      (PRODUCT GENERATION RATE / PRH0) = (BETAH * Q0/PRH0)
C      *(ENERGY GENERATION RATE / Q0)
C
C      USED WHEN PRODH=1.
C      READ IN DIMENSIONS OF PRODUCT UNITS/(SEC*KW).
C C1     DIMENSIONLESS GROUP.
C C2     DIMENSIONLESS GROUP.
C C3D    DIMENSIONLESS GROUP.
C C3H    DIMENSIONLESS GROUP.
C CNDSP  DIMENSIONLESS SPECIFIED DETECTABLE PRODUCT CONCENTRATION
C      CORRESPONDING TO CNDS(I).
C CNHAZS SPECIFIED HAZARDOUS PRODUCT CONCENTRATION CORRESPONDING TO
C      A PARTICULAR CNHS(L). IN UNITS OF AMOUNT OF PRODUCT PER UNIT
C      MASS OF BULK GAS.
C CNDS(I) SPECIFIED DETECTABLE PRODUCT CONCENTRATION. UNITS OF AMOUNT
C      OF PRODUCT PER UNIT MASS OF BULK GAS.
C CNHS(L) SPECIFIED HAZARDOUS PRODUCT CONCENTRATION. UNITS OF AMOUNT
C      OF PRODUCT PER UNIT MASS OF BULK GAS.
C DELTA  THE HEIGHT OF THE FIRE ABOVE THE FLOOR IN FEET.
C DELTAM THE HEIGHT OF THE FIRE ABOVE THE FLOOR IN METERS.
C DPHI   DPHI/DTAU GENERATED IN SUBF DURING COURSE OF INTEGRATION.
C DPHIDS DIMENSIONLESS RATE OF TEMP RISE CORRESPONDING TO RRDSPF(I).
C DPRD0  DPRD/DTAU AT TIME TAU=0. (DETECTABLE PRODUCT)
C DPRHT0 DPRH/DTAU AT TIME TAU=0. (HAZARDOUS PRODUCT)
C DQD0   DQ/DTAU AT TIME TAU=0.
C FIRE   INDICATES THE REPRESENTATIVE FORM OF ENERGY GENERATION RATE FOR
C      THE PARTICULAR COMPUTER RUN; WHEN FIRE=1, MULTI-EXPONENTIAL
C      FIRE GROWTH CURVE. WHEN FIRE=2, DIGITAL DATA INPUT. WHEN
C      FIRE=3, SOME OTHER ANALYTIC FIRE GROWTH FUNCTION (NONE
C      PRESENTLY INCORPORATED INTO THE PROGRAM).
C FLAG   INDICATOR OF WHICH DETECTION METHOD IS UNDER CONSIDERATION.
C      WHEN FLAG=1, DETECTION BY POC CONCENTRATION.
C      WHEN FLAG=2, DETECTION BY UPPER LAYER TEMPERATURE.
C      WHEN FLAG=3, DETECTION BY RATE OF TEMPERATURE RISE.
C      THE VALUE OF FLAG IS ASSIGNED BY THE PROGRAM. THE VALUE,
C      1, 2, OR 3, IT RECEIVES IS DEPENDENT ON THE INPUT VALUES
C      OF NCND, NTMD, AND NRRD.
C HCOMB  THE HEAT OF COMBUSTION (IN KJ/KG) USED TO CONVERT DIGITAL
C      DATA, QDATA(N), INPUT AS MASS LOSS RATES TO ENERGY RELEASE
C      RATES. IF QDATA(N) ARE INPUT DIRECTLY AS ENERGY RELEASE RATES
C      IN KW, THEN INPUT HCOMB=1.0.
C HF(I)  COMPARTMENT CEILING HEIGHT IN FEET.
C HM(I)  COMPARTMENT CEILING HEIGHT IN METERS.

```

MAIN PROGRAM

C IDETH INDICATOR OF WHETHER OR NOT DETECTION BY CONCENTRATION
 C IS TO BE CONSIDERED IN SUBROUTINE AINT.
 C IF IDETH=0, DETECTION BY CONCENTRATION WILL BE
 C CONSIDERED.
 C IF IDETH=1, DETECTION BY CONCENTRATION WILL NOT BE
 C CONSIDERED.
 C THE VALUE, 1 OR 0, OF IDETH IS ASSIGNED BY THE PROGRAM
 C BASED ON THE PRESENT VALUE OF FLAG. IDETH IS A
 C VARIABLE.
 C IDETR ANALOGOUS TO IDETH FOR DETECTION BY RATE OF TEMPERATURE
 C RISE OF UPPER LAYER.
 C IDETT ANALOGOUS TO IDETH FOR DETECTION BY UPPER LAYER TEMP.
 C INTER INDICATOR OF WHETHER INTERACTIVE OR BATCH MODE IS BEING USED.
 C IF INTER=YES, INTERACTIVE MODE.
 C IF INTER=NO, BATCH MODE.
 C LINTER LOGICAL EQUIVALENT TO INTER.
 C IF LINTER=TRUE, INTERACTIVE MODE.
 C IF LINTER=FALSE, BATCH MODE.
 C LNORM LOGICAL EQUIVALENT TO NORM.
 C IF LNORM=TRUE, NORMALIZED OUTPUT.
 C IF LNORM=FALSE, DO NOT NORMALIZE OUTPUT.
 C NCND THE NUMBER OF CASES OF DETECTION BY CONCENTRATION.
 C NCNH THE NUMBER OF HAZARDOUS PRODUCT CONCENTRATIONS CONSIDERED.
 C NDET UPPER BOUND OF A DO LOOP. NDET IS SET EQUAL TO THE NUMBER
 C OF CASES OF DETECTION BY THE SPECIFIC MEANS OF DETECTION OF
 C INTEREST. I.E., THE PROGRAM GOES THROUGH NCND FIRST (IF
 C NCND IS NOT EQUAL TO 0), SETTING NDET=NCND AND GOING
 C THROUGH ALL CASES OF DETECTION BY CONCENTRATION. THE
 C NUMBER OF CASES OF DETECTION BY UPPER LAYER TEMPERATURE,
 C NTMD, IS GONE THROUGH SECOND AND NRRD THIRD.
 C NH THE NUMBER OF ROOM HEIGHTS TO BE CONSIDERED.
 C NORM INDICATOR OF WHETHER OR NOT FIRE DATA OUTPUT SHOULD BE
 C NORMALIZED.
 C IF NORM=YES, NORMALIZED OUTPUT.
 C IF NORM=NO, DO NOT NORMALIZE OUTPUT.
 C NPTSP THE NUMBER OF (TIME,PRODUCT) DIGITAL DATA POINTS TO BE INPUT
 C WHEN WORKING WITH DIGITAL DATA.
 C NPTSQ THE NUMBER OF (TIME,ENERGY GENERATION RATE) DIGITAL DATA POINTS
 C TO BE INPUT WHEN WORKING WITH DIGITAL DATA.
 C NRRD THE NUMBER OF CASES FOR DETECTION BY RATE OF TEMPERATURE
 C RISE OF THE UPPER LAYER.
 C NS THE NUMBER OF ROOM AREAS TO BE CONSIDERED.
 C NSEGPD USED WHEN PRODD=2. NUMBER OF SEGMENTS OF THE PRODUCT GENERATION
 C RATE HISTORY (DETECTABLE PRODUCT).
 C NSEGPH USED WHEN PRODH=2. NUMBER OF SEGMENTS OF THE PRODUCT GENERATION
 C RATE HISTORY (HAZARDOUS PRODUCT).
 C NSEGO USED WHEN FIRE =1 OR 2. THE NUMBER OF SEGMENTS OF THE ENERGY
 C GENERATION RATE HISTORY.
 C NSEGM1 THE NUMBER OF SEGMENTS MINUS 1. I.E., NSEGO-1.
 C NTMD THE NUMBER OF CASES FOR DETECTION BY TEMP OF THE LAYER.
 C NTMHU THE NUMBER OF SPECIFIED HAZARDOUS LAYER TEMPERATURES TO
 C BE CONSIDERED WHEN INTERFACE IS ABOVE ZETEYE.
 C NTMHL THE NUMBER OF SPECIFIED HAZARDOUS LAYER TEMPERATURES TO
 C BE CONSIDERED WHEN INTERFACE IS BELOW ZETEYE.
 C PHIDSP DIMENSIONLESS DETECTION TEMPERATURE CORRESPONDING TO TMDSPF(I).
 C PHIHSU DIMENSIONLESS HAZARDOUS TEMPERATURE CORRESPONDING TO
 C TMHSUF(I).
 C PHIHSL DIMENSIONLESS HAZARDOUS TEMPERATURE CORRESPONDING TO

MAIN PROGRAM

```

C      TMHSLF(I).
C PRD(N)  IF PRODD =2 (LINEAR INTERPOLATION BETWEEN DATA POINTS):
C          AT INPUT, THE PRD(N) ARE READ IN AS PRODUCT GENERATION
C          RATES IN PRODUCT UNITS PER SECOND AT THE END OF SEGMENT N.
C          THIS VECTOR IS NORMALIZED BY DIVIDING EACH COMPONENT
C          BY PRD0. HERE N=1,.....NSEGPD. (DETECTABLE PRODUCT)
C PRH(N)  IF PRODH =2 (LINEAR INTERPOLATION BETWEEN DATA POINTS):
C          AT INPUT, THE PRH(N) ARE READ IN AS PRODUCT GENERATION
C          RATES IN PRODUCT UNITS PER SECOND AT THE END OF SEGMENT N.
C          THIS VECTOR IS NORMALIZED BY DIVIDING EACH COMPONENT
C          BY PRH0. HERE N=1,.....NSEGPH. (HAZARDOUS PRODUCT)
C PRODD  INDICATES THE REPRESENTATIVE FORM OF DETECTABLE COMBUSTION
C          PRODUCT GENERATION RATE FOR THE PARTICULAR COMPUTER RUN. WHEN
C          PRODD=1 PRODUCT GENERATION RATE IS DIRECTLY PROPORTIONAL
C          TO ENERGY GENERATION RATE THROUGH A FIXED CONSTANT OF PROPOR-
C          TIONALITY, BETAD. WHEN PRODD=2, DIGITAL DATA FOR PRODUCT
C          GENERATION WITH LINEAR INTERPOLATION IS SUPPLIED. WHEN
C          PRODD=3, SOME ANALYTIC GENERATION IS PRESCRIBED (NONE PRESENTLY
C          AVAILABLE).
C PRODH  INDICATES THE REPRESENTATIVE FORM OF HAZARDOUS COMBUSTION
C          PRODUCT GENERATION RATE FOR THE PARTICULAR COMPUTER RUN. WHEN
C          PRODH=1 PRODUCT GENERATION RATE IS DIRECTLY PROPORTIONAL
C          TO ENERGY GENERATION RATE THROUGH A FIXED CONSTANT OF PROPOR-
C          TIONALITY, BETAH. WHEN PRODH=2 DIGITAL DATA FOR PRODUCT
C          GENERATION WITH LINEAR INTERPOLATION IS SUPPLIED. WHEN
C          PRODH=3 SOME ANALYTIC GENERATION IS PRESCRIBED (NONE PRESENTLY
C          AVAILABLE).
C PRD0  INITIAL DETECTABLE PRODUCT GENERATION RATE IN PRODUCT UNITS
C          PER SECOND.
C PRH0  INITIAL HAZARDOUS PRODUCT GENERATION RATE IN PRODUCT UNITS
C          PER SECOND.
C Q(N)  IF FIRE =2 (LINEAR INTERPOLATION BETWEEN DATA POINTS):
C          AT INPUT, THE Q(N) ARE READ IN AS ENERGY GENERATION
C          RATES IN KW (OR MASS LOSS RATE IF HCOMB#1.) AT THE END
C          OF SEGMENT N. THIS VECTOR IS THEN NORMALIZED BY DIVID-
C          ING EACH COMPONENT BY Q0. HERE N=1,.....NSEGQ.
C          IF FIRE =1 (EXPONENTIAL INTERPOLATION BETWEEN DATA POINTS):
C          AT INPUT, THE Q(N) ARE IMMEDIATELY READ IN A NORMAL-
C          IZED FORM AS ENERGY GENERATION RATES IN KW AT THE END
C          OF SEGMENT N DIVIDED BY Q0. HERE N=1,.....NSEGQ-1.
C          IF NSEGQ=1 THEN Q(N) IS NOT USED.
C Q0  THE INITIAL POWER OF THE FIRE IN KW. INPUT FOR
C      DIGITAL DATA. DETERMINED BY PROGRAM FOR MULTI-EXPONENTIAL
C      CURVE.
C RRDSPC(I) SPECIFIED RATE OF TEMPERATURE RISE OF LAYER FOR
C            DETECTION IN DEGREES C PER MINUTE.
C RRDSPF(I) SPECIFIED RATE OF TEMPERATURE RISE OF LAYER FOR
C            DETECTION IN DEGREES F PER MINUTE.
C SF(I)  ROOM AREA IN SQUARE FEET.
C SM(I)  ROOM AREA IN SQUARE METERS.
C TAULIM MAXIMUM TAU FOR WHICH FIRE IS MODELED OR TAU WHEN FIRE IS OUT.
C          DIMENSIONS IN SECONDS.
C TAUPRD(N) TIME IN SECONDS AT THE END OF THE NTH DETECTABLE PRODUCT
C            SEGMENT. READ IN FOR LINEAR INTERPOLATION BETWEEN DATA
C            POINTS, I.E., IF PRODD=2.
C TAUPRH(N) TIME IN SECONDS AT THE END OF THE NTH HAZARDOUS PRODUCT
C            SEGMENT. READ IN FOR LINEAR INTERPOLATION BETWEEN DATA
C            POINTS, I.E., IF PRODH=2.

```

MAIN PROGRAM

```

C TAUQ(N) TIME IN SECONDS AT THE END OF THE NTH ENERGY SEGMENT. READ
C     IN FOR LINEAR INTERPOLATION BETWEEN DATA POINTS, I.E., IF
C     FIRE=2. COMPUTED FOR EXPONENTIAL INTERPOLATION BETWEEN DATA
C     POINTS, I.E., IF FIRE=1.
C TMDSPC(I) SPECIFIED LAYER TEMPERATURE FOR DETECTION IN DEGREES C.
C TMDSPF(I) SPECIFIED LAYER TEMPERATURE FOR DETECTION IN DEGREES F.
C TMHSUC(I) SPECIFIED HAZARDOUS LAYER TEMPERATURE WHEN INTERFACE IS
C     ABOVE ZETEYE IN DEGREES C.
C TMHSUF(I) SPECIFIED HAZARDOUS LAYER TEMPERATURE WHEN INTERFACE IS
C     ABOVE ZETEYE IN DEGREES F.
C TMHSLC(I) SPECIFIED HAZARDOUS LAYER TEMPERATURE WHEN INTERFACE IS
C     BELOW ZETEYE IN DEGREES C.
C TMHSLF(I) SPECIFIED HAZARDOUS LAYER TEMPERATURE WHEN INTERFACE IS
C     BELOW ZETEYE IN DEGREES F.
C WRC     WRITE/SUPPRESS CODE
C     IF WRC=1, SUMMARY OUTPUT, 132 CHARACTERS PER LINE.
C     IF WRC=2, SUMMARY OUTPUT, 80 CHARACTERS PER LINE.
C     IF WRC=3, FULL OUTPUT, 132 CHARACTERS PER LINE.
C     IF WRC=4, FULL OUTPUT, 80 CHARACTERS PER LINE.
C ZETEYE  THE SPECIFIED HEIGHT OF EYELEVEL ABOVE THE FLOOR IN FEET. IF
C     INTERFACE DROPS BELOW THIS LEVEL THEN THE ONSET OF HAZARDOUS
C     CONDITIONS WILL OCCUR WHEN UPPER LAYER TEMPERATURE EXCEEDS
C     TMHSLF(I).
C ZETO    THE INITIAL HEIGHT OF THE INTERFACE FROM THE FLOOR = HF(K)
C ZEYEF   THE INPUT SPECIFIED HEIGHT (IN FEET) OF EYELEVEL FROM THE FLOOR
C     FOR HAZARD.
C ZEYEM   THE INPUT SPECIFIED HEIGHT (IN METERS) OF EYELEVEL FROM THE
C     FLOOR FOR HAZARD.
C
C*****
C
C     INTEGER FIRE,FLAG,WRC,TITLE(20),PRODD,PRODH
C     DIMENSION CNDS(10),TMDSPF(10),TMDSPC(10),CNHS(10),HF(20),HM(20),
2         SF(30),SM(30),TMHSUF(10),TMHSLF(10),TMHSUC(10),
3         TMHSLC(10),RRDSPF(10),RRDSPC(10)
C     COMMON NSEGQ,NSEGP,NSEGP,TAUQ(100),TAUPRD(100),TAUPRH(100),
2         Q(100),PRD(100),PRH(100),AKAP(100),C1,C2,C3D,C3H,ZETO,FIRE,
3         PRODD,PRODH,LIMIT,DPHI,TAULIM,LINTER,DELTA,DQDT0,DPRDT0,
4         DPRHT0,Q0,LNORM
C     LOGICAL LINTER,LNORM
C     CHARACTER YES,NO,BATCH,INTER,NORM,ICHECK,INFO,CHARTR
C     EXTERNAL F
C     DATA YES,NO,BATCH/'Y','N','B'/
C
C     WRITE (6,2400)
C     WRITE (6,2430)
C     WRITE (6,2400)
C     WRITE (6,1860)
C     READ (5,1530) INTER
C     IF (INTER.EQ.YES) LINTER=.TRUE.
C     IF ((INTER.EQ.NO).OR.(INTER.EQ.BATCH)) LINTER=.FALSE.
C     IF (LINTER) WRITE (6,2400)
C     IF (LINTER) WRITE (6,1870)
C     IF (LINTER) WRITE (6,2400)
C     IF (LINTER) WRITE (6,1510)
10    IF (LINTER) WRITE (6,2400)
C     IF (LINTER) WRITE (6,1880)
C     READ (5,1520) TITLE

```


MAIN PROGRAM

```

IF (LINTER) WRITE (6,2410)
WRITE (6,1570) TITLE
IF (.NOT.(LINTER)) GO TO 20
WRITE (6,1940)
READ (5,1530) ICHECK
20 IF (ICHECK.EQ.NO) GO TO 10
IF (LINTER) WRITE (6,2400)
IF (LINTER) WRITE (6,1890)
READ (5,1550,ERR=30) WRC
IF (LINTER) WRITE (6,2410)
IF (WRC.EQ.1) WRITE (6,1900)
IF (WRC.EQ.2) WRITE (6,1910)
IF (WRC.EQ.3) WRITE (6,1920)
IF (WRC.EQ.4) WRITE (6,1930)
IF (.NOT.(LINTER)) GO TO 50
WRITE (6,1940)
READ (5,1530) ICHECK
IF (ICHECK.EQ.NO) GO TO 20
GO TO 50
30 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 20
40 WRITE (6,2450)
STOP 1

C
C INPUT DATA IN ENGLISH UNITS AND CONVERT SAME TO METRIC UNITS.
C
50 IF (LINTER) WRITE (6,2400)
IF (LINTER) WRITE (6,1950)
IF (.NOT.(LINTER)) GO TO 60
READ (5,1530) INFO
IF (INFO.EQ.YES) WRITE (6,1960)
WRITE (6,1970)
60 READ (5,*,ERR=70) ALAMR,ALAMC,ZEYEF,DELTA
IF (LINTER) WRITE (6,2410)
WRITE (6,1540) ALAMR,ALAMC,ZEYEF,DELTA
IF (.NOT.(LINTER)) GO TO 80
WRITE (6,1940)
READ (5,1530) ICHECK
IF (ICHECK.EQ.NO) GO TO 50
GO TO 80
70 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 50
GO TO 40
80 DELTAM=DELTA*0.3048
ZEYEM=ZEYEF*0.3048
IF (LINTER) WRITE (6,2400)
IF (LINTER) WRITE (6,1980)
IF (LINTER) WRITE (6,2400)
IF (LINTER) WRITE (6,1990)
IF (LINTER) WRITE (6,2400)
I=1
NTMD=0
90 IF (LINTER) WRITE (6,2000)
READ (5,*,ERR=100,END=110) TMDSPF(I)
IF (LINTER) WRITE (6,2410)
WRITE (6,*) TMDSPF(I)
IEND=0
IF (LINTER) CALL INPUT (TMDSPF(I),IEND)

```


MAIN PROGRAM

```

IF (IEND.EQ.999) GO TO 110
NTMD=NTMD+1
TMDSPC(I)=(TMDSPF(I)-32.)/1.8
I=I+1
IF (LINTER) WRITE (6,2410)
GO TO 90
100 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 90
GO TO 40
110 I=1
NRRD=0
IF (LINTER) WRITE (6,2400)
120 IF (LINTER) WRITE (6,2010)
READ (5,*,ERR=130,END=140) RRDSPF(I)
IF (LINTER) WRITE (6,2410)
WRITE (6,*) RRDSPF(I)
IF ((RRDSPF(I).GT.-0.0001).AND.(RRDSPF(I).LT.0.0001))
2 WRITE (6,2020)
IEND=0
IF (LINTER) CALL INPUT (RRDSPF(I),IEND)
IF (IEND.EQ.999) GO TO 140
NRRD=NRRD+1
RRDSPC(I)=RRDSPF(I)/1.8
I=I+1
IF (LINTER) WRITE (6,2410)
GO TO 120
130 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 120
GO TO 40
140 I=1
NCND=0
IF (LINTER) WRITE (6,2400)
150 IF (LINTER) WRITE (6,2030)
READ (5,*,ERR=160,END=170) CNDS(I)
IF (LINTER) WRITE (6,2410)
WRITE (6,*) CNDS(I)
IEND=0
IF (LINTER) CALL INPUT (CNDS(I),IEND)
IF (IEND.EQ.999) GO TO 170
NCND=NCND+1
I=I+1
IF (LINTER) WRITE (6,2410)
GO TO 150
160 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 150
GO TO 40
170 IF (LINTER) WRITE (6,2400)
IF (LINTER) WRITE (6,2040)
I=1
NTMHU=0
IF (LINTER) WRITE (6,2400)
180 IF (LINTER) WRITE (6,2050)
READ (5,*,ERR=190,END=200) TMHSUF(I)
IF (LINTER) WRITE (6,2410)
WRITE (6,*) TMHSUF(I)
IEND=0
IF (LINTER) CALL INPUT (TMHSUF(I),IEND)
IF (IEND.EQ.999) GO TO 200

```

MAIN PROGRAM

```

NTMHU=NTMHU+1
TMHSUC(I)=(TMHSUF(I)-32.)/1.8
I=I+1
IF (LINTER) WRITE (6,2410)
GO TO 180
190 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 180
GO TO 40
200 I=1
NTMHL=0
IF (LINTER) WRITE (6,2400)
210 IF (LINTER) WRITE (6,2060)
READ (5,*,ERR=220,END=230) TMHSLF(I)
IF (LINTER) WRITE (6,2410)
WRITE (6,*) TMHSLF(I)
IEND=0
IF (LINTER) CALL INPUT (TMHSLF(I),IEND)
IF (IEND.EQ.999) GO TO 230
NTMHL=NTMHL+1
TMHSLC(I)=(TMHSLF(I)-32.)/1.8
I=I+1
IF (LINTER) WRITE (6,2410)
GO TO 210
220 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 210
GO TO 40
230 I=1
NCNH=0
IF (LINTER) WRITE (6,2400)
240 IF (LINTER) WRITE (6,2070)
READ (5,*,ERR=250,END=260) CNHS(I)
IF (LINTER) WRITE (6,2410)
WRITE (6,*) CNHS(I)
IEND=0
IF (LINTER) CALL INPUT (CNHS(I),IEND)
IF (IEND.EQ.999) GO TO 260
NCNH=NCNH+1
I=I+1
IF (LINTER) WRITE (6,2410)
GO TO 240
250 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 240
GO TO 40
260 IF (LINTER) WRITE (6,2400)
IF (LINTER) WRITE (6,2080)
IF (LINTER) WRITE (6,2400)
I=1
NH=0
270 IF (LINTER) WRITE (6,2090)
READ (5,*,ERR=280,END=290) HF(I)
IF (LINTER) WRITE (6,2410)
WRITE (6,*) HF(I)
IEND=0
IF (LINTER) CALL INPUT (HF(I),IEND)
IF (IEND.EQ.999) GO TO 290
NH=NH+1
I=I+1
IF (LINTER) WRITE (6,2410)

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MAIN PROGRAM

```

GO TO 270
280  IF (LINTER) WRITE (6,2440)
    IF (LINTER) GO TO 270
GO TO 40
290  DO 310 IS=1,NH
      DO 300 JS=1,NH
        IF (HF(IS).LE.HF(JS)) GO TO 300
        IF (IS.GE.JS) GO TO 300
        TSTORE=HF(IS)
        HF(IS)=HF(JS)
        HF(JS)=TSTORE
300    CONTINUE
310    CONTINUE
DO 320 IM=1,NH
320    HM(IM)=HF(IM)*0.3048
    I=1
    NS=0
    IF (LINTER) WRITE (6,2400)
330    IF (LINTER) WRITE (6,2100)
    READ (5,*,ERR=340,END=350) SF(I)
    IF (LINTER) WRITE (6,2410)
    WRITE (6,*) SF(I)
    IEND=0
    IF (LINTER) CALL INPUT (SF(I),IEND)
    IF (IEND.EQ.999) GO TO 350
    NS=NS+1
    I=I+1
    IF (LINTER) WRITE (6,2410)
    GO TO 330
340    IF (LINTER) WRITE (6,2440)
    IF (LINTER) GO TO 330
    GO TO 40
350    DO 370 IS=1,NS
      DO 360 JS=1,NS
        IF (SF(IS).LE.SF(JS)) GO TO 360
        IF (IS.GE.JS) GO TO 360
        TSTORE=SF(IS)
        SF(IS)=SF(JS)
        SF(JS)=TSTORE
360    CONTINUE
370    CONTINUE
DO 380 IM=1,NS
380    SM(IM)=SF(IM)*0.0929
C
C THIS SECTION INPUTS DATA FOR FIRE ENERGY GENERATION RATE.
C
    IF (LINTER) WRITE (6,2400)
    IF (LINTER) WRITE (6,2110)
    IF (LINTER) WRITE (6,2400)
390    IF (LINTER) WRITE (6,2120)
    READ (5,1550,ERR=400) FIRE
    IF (LINTER) WRITE (6,2410)
    IF (FIRE.EQ.1) WRITE (6,2130)
    IF (FIRE.EQ.2) WRITE (6,2140)
    IF (.NOT.(LINTER)) GO TO 410
    WRITE (6,1940)
    READ (5,1530) ICHECK
    IF (ICHECK.EQ.NO) GO TO 390

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MAIN PROGRAM

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      GO TO 410
400   IF (LINTER) WRITE (6,2440)
      IF (LINTER) GO TO 390
      GO TO 40
410   GO TO (420,500,590), FIRE
C
C INPUT DATA FOR MULTI-EXPONENTIAL FIRE GROWTH CURVE.
C
420   IF (LINTER) WRITE (6,2410)
      IF (LINTER) WRITE (6,2150)
      READ (5,*,ERR=430) TAULIM
      IF (LINTER) WRITE (6,2410)
      WRITE (6,*) TAULIM
      IF (LINTER) CALL INPUT (TAULIM,0)
      IF (LINTER) WRITE (6,2410)
      IF (LINTER) WRITE (6,2160)
      GO TO 440
430   IF (LINTER) WRITE (6,2440)
      IF (LINTER) GO TO 420
      GO TO 40
440   N=1
450   READ (5,*,ERR=460,END=470) Q(N),AKAP(N)
      N=N+1
      GO TO 450
460   IF (LINTER) WRITE (6,2440)
      IF (LINTER) GO TO 450
      GO TO 40
470   NSEGQ=N-1
      ITYPE=1
      IF (LINTER) WRITE (6,2410)
      WRITE (6,2170) (N,Q(N),AKAP(N),N=1,NSEGQ)
      IF (LINTER) CALL INPUT2 (AKAP,Q,ITYPE)
      Q0=Q(1)
      NSEGM1=NSEGQ-1
      DO 480 N=1,NSEGM1
          Q(N)=Q(N+1)/Q0
480   CONTINUE
      DQDT0=AKAP(1)
490   IF (LINTER) WRITE (6,2180)
      READ (5,1530) NORM
      IF (NORM.EQ.YES) LNORM=.TRUE.
      IF (NORM.EQ.NO) LNORM=.FALSE.
      IF (LNORM) WRITE (6,2190)
      IF (.NOT.(LNORM)) WRITE (6,2200)
      IF (.NOT.(LINTER)) GO TO 600
      WRITE (6,1940)
      READ (5,1530) ICHECK
      IF (ICHECK.EQ.NO) GO TO 490
      GO TO 600
C
C INPUT THE VALUE OF TAUQ AND Q AT EACH DIGITAL DATA
C SEGMENT, NSEGQ.
C
500   IF (LINTER) WRITE (6,2410)
      IF (LINTER) WRITE (6,2210)
      READ (5,*,ERR=510) TAULIM,HCOMB
      IF (LINTER) WRITE (6,2410)
      WRITE (6,2220) TAULIM,HCOMB

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MAIN PROGRAM

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IF (.NOT.(LINTER)) GO TO 520
WRITE (6,1940)
READ (5,1530) ICHECK
IF (ICHECK.EQ.NO) GO TO 500
GO TO 520
510 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 500
GO TO 40
520 IF (LINTER) WRITE (6,2410)
IF (LINTER) WRITE (6,2230)
READ (5,*,ERR=530) Q0
IF (LINTER) WRITE (6,2410)
WRITE (6,2240) Q0
IF (LINTER) CALL INPUT (Q0,0)
IF (LINTER) WRITE (6,2410)
IF (LINTER) WRITE (6,2250)
GO TO 540
530 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 520
GO TO 40
540 N=1
550 READ (5,*,ERR=560,END=570) TAUQ(N),Q(N)
N=N+1
GO TO 550
560 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 550
GO TO 40
570 NSEGQ=N-1
ITYPE=2
IF (LINTER) WRITE (6,2410)
WRITE (6,1730) (N,TAUQ(N),N,Q(N),N=1,NSEGQ)
IF (LINTER) CALL INPUT2 (TAUQ,Q,ITYPE)
580 IF (LINTER) WRITE (6,2260)
READ (5,1530) NORM
IF (NORM.EQ.YES) LNORM=.TRUE.
IF (NORM.EQ.NO) LNORM=.FALSE.
IF (LNORM) WRITE (6,2190)
IF (.NOT.(LNORM)) WRITE (6,2200)
IF (.NOT.(LINTER)) GO TO 600
WRITE (6,1940)
READ (5,1530) ICHECK
IF (ICHECK.EQ.NO) GO TO 580
GO TO 600

C
C ENERGY GENERATION RATE GIVEN BY ANALYTIC FUNCTION
C
590 WRITE (6,1600)
IF (LINTER) GO TO 350
STOP 2

C
C THIS SECTION INPUTS DATA FOR DETECTABLE PRODUCT GENERATION RATE.
C
600 IF (LINTER) WRITE (6,2400)
IF (LINTER) WRITE (6,2270)
IF (LINTER) WRITE (6,2400)
IF (NCND.EQ.0) WRITE (6,2380)
IF (NCND.EQ.0) GO TO 650
610 IF (LINTER) WRITE (6,2280)

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MAIN PROGRAM

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READ (5,1550,ERR=620) PRODD
IF (LINTER) WRITE (6,2410)
IF (PRODD.EQ.1) WRITE (6,2290)
IF (PRODD.EQ.2) WRITE (6,2300)
IF (.NOT.(LINTER)) GO TO 630
WRITE (6,1940)
READ (5,1530) ICHECK
IF (ICHECK.EQ.NO) GO TO 610
GO TO 630
620 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 610
GO TO 40
630 GO TO (640,670,730), PRODD
C
C INPUT BETAD FOR DETECTABLE PRODUCT GENERATION RATE
C PROPORTIONAL TO ENERGY RELEASE.
C
640 IF (LINTER) WRITE (6,2410)
IF (LINTER) WRITE (6,2310)
READ (5,*,ERR=660) BETAD
IF (LINTER) WRITE (6,2410)
WRITE (6,*) BETAD
IF (LINTER) CALL INPUT (BETAD,0)
650 IF (NCND.EQ.0) BETAD=0.0
IF (NCND.EQ.0) PRODD=1
GO TO 740
660 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 640
GO TO 40
C
C INPUT THE VALUE OF TAUPRD AND PRD AT THE END OF EACH DIGITAL
C DATA SEGMENT, NSEGPD.
C
670 IF (LINTER) WRITE (6,2410)
IF (LINTER) WRITE (6,2340)
READ (5,*,ERR=680) PRD0
IF (LINTER) WRITE (6,2410)
WRITE (6,*) PRD0
IF (LINTER) CALL INPUT (PRD0,0)
IF (LINTER) WRITE (6,2410)
IF (LINTER) WRITE (6,2350)
GO TO 690
680 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 670
GO TO 40
690 N=1
700 READ (5,*,ERR=710,END=720) TAUPRD(N),PRD(N)
N=N+1
GO TO 700
710 IF (LINTER) WRITE (6,2440)
IF (LINTER) GO TO 700
GO TO 40
720 NSEGPD=N-1
ITYPE=3
IF (LINTER) WRITE (6,2410)
WRITE (6,1710) (N,TAUPRD(N),N,PRD(N),N=1,NSEGPD)
IF (LINTER) CALL INPUT2 (TAUPRD,PRD,ITYPE)
GO TO 740

```

MAIN PROGRAM

```

C
C DETECTABLE PRODUCT GENERATION RATE GIVEN BY ANALYTIC FUNCTION
C
750  WRITE (6,1660)
      IF (LINTER) GO TO 600
      STOP 3

C
C THIS SECTION INPUTS DATA FOR HAZARDOUS PRODUCT GENERATION RATE.
C
740  IF (LINTER) WRITE (6,2400)
      IF (LINTER) WRITE (6,2330)
      IF (LINTER) WRITE (6,2400)
750  IF (LINTER) WRITE (6,2280)
      READ (5,1550,ERR=760) PRODH
      IF (LINTER) WRITE (6,2410)
      IF (PRODH.EQ.1) WRITE (6,2290)
      IF (PRODH.EQ.2) WRITE (6,2300)
      IF (.NOT.(LINTER)) GO TO 770
      WRITE (6,1940)
      READ (5,1530) ICHECK
      IF (ICHECK.EQ.NO) GO TO 750
      GO TO 770
760  IF (LINTER) WRITE (6,2440)
      IF (LINTER) GO TO 750
      GO TO 40
770  GO TO (780,800,860), PRODH

C
C INPUT BETAH FOR HAZARDOUS PRODUCT GENERATION RATE
C PROPORTIONAL TO ENERGY RELEASE.
C
780  IF (LINTER) WRITE (6,2410)
      IF (LINTER) WRITE (6,2320)
      READ (5,*,ERR=790) BETAH
      IF (LINTER) WRITE (6,2410)
      WRITE (6,*) BETAH
      IF (LINTER) CALL INPUT (BETAH,0)
      GO TO 870
790  IF (LINTER) WRITE (6,2440)
      IF (LINTER) GO TO 780
      GO TO 40

C
C INPUT THE VALUE OF TAUPRH AND PRH AT THE END OF EACH DIGITAL
C DATA SEGMENT, NSEGPH.
C
800  IF (LINTER) WRITE (6,2410)
      IF (LINTER) WRITE (6,2360)
      READ (5,*,ERR=810) PRH0
      IF (LINTER) WRITE (6,2410)
      WRITE (6,*) PRH0
      IF (LINTER) CALL INPUT (PRH0,0)
      IF (LINTER) WRITE (6,2410)
      IF (LINTER) WRITE (6,2370)
      GO TO 820
810  IF (LINTER) WRITE (6,2440)
      IF (LINTER) GO TO 800
      GO TO 40
820  N=1
830  READ (5,*,ERR=840,END=850) TAUPRH(N),PRH(N)

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MAIN PROGRAM

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N=N+1
GO TO 830
840 IF (LINTER) WRITE (6,2440)
    IF (LINTER) GO TO 830
    GO TO 40
850 NSEGPB=N-1
    ITYPE=4
    IF (LINTER) WRITE (6,2410)
    WRITE (6,1720) (N,TAUPRH(N),N,PRH(N),N=1,NSEGPB)
    IF (LINTER) CALL INPUT2 (TAUPRH,PRH,ITYPE)
    GO TO 870
C
C HAZARDOUS PRODUCT GENERATION RATE ANALYTIC FUNCTION
C
860 WRITE (6,1560)
    IF (LINTER) GO TO 740
    STOP 4
870 IF (LINTER) WRITE (6,2390)
    IF (LINTER) READ (5,1530) CHARTR
    IF ((WRC.EQ.2).OR.(WRC.EQ.4)) GO TO 1050
    WRITE (6,1560) TITLE
    IF (FIRE.EQ.2) GO TO 880
    WRITE (6,1580) TAULIM,Q0
    IF (LINTER) WRITE (6,2390)
    IF (LINTER) READ (5,1530) CHARTR
    CALL EXFIRE
    GO TO 930
880 WRITE (6,1610) TAULIM,Q0,HCOMB
    IF (LINTER) WRITE (6,2390)
    IF (LINTER) READ (5,1530) CHARTR
    DO 890 N=1,NSEGPB
        WRITE (6,1730) N,TAUQ(N),N,Q(N)
890     CONTINUE
    IF (Q0.GT.0.0) GO TO 910
    DO 900 N=1,NSEGPB
        IF (Q(N).GT.0.0) Q0=Q(N)/100.0
        IF (Q0.GT.0.0) GO TO 910
900     CONTINUE
910 Q0=Q0*HCOMB
    DO 920 N=1,NSEGPB
        Q(N)=Q(N)*HCOMB/Q0
920     QQDT0=(Q(1)-1.)/TAUQ(1)
930 IF (LINTER) WRITE (6,2390)
    IF (LINTER) READ (5,1530) CHARTR
    WRITE (6,1740) ALAMR,ALAMC,DELTA,DELTAM
    IF (NCND.EQ.0.0) PRD0=0.0
    IF (NCND.EQ.0.0) DPRDT0=0.0
    IF (NCND.EQ.0) GO TO 990
    IF (PRODD.EQ.2) GO TO 940
    WRITE (6,1620) BETAD
    PRD0=BETAD*Q0
    DPRDT0=QQDT0
    GO TO 990
940 WRITE (6,1670) PRD0
    DO 950 N=1,NSEGPB
        WRITE (6,1710) N,TAUPRD(N),N,PRD(N)
950     CONTINUE
    IF (PRD0.GT.0.0) GO TO 970

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MAIN PROGRAM

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DO 960 N=1,NSEGPD
    IF (PRD(N).GT.0.0) PRD0=PRD(N)/100.0
    IF (PRD0.GT.0.0) GO TO 970
960    CONTINUE
970    DO 980 N=1,NSEGPD
980        PRD(N)=PRD(N)/PRD0
        DPRDT0=(PRD(N)-1.)/TAUPRD(1)
990    IF (LINTER) WRITE (6,2390)
        IF (LINTER) READ (5,1530) CHARTR
        IF (PRODH.EQ.2) GO TO 1000
        WRITE (6,1630) BETAH
        PRD0=BETAH*Q0
        DPRHT0=DQD0
        GO TO 1230
1000    WRITE (6,1680) PRH0
        DO 1010 N=1,NSEGPB
            WRITE (6,1720) N,TAUPRH(N),N,PRH(N)
1010        CONTINUE
            IF (PRH0.GT.0.0) GO TO 1030
            DO 1020 N=1,NSEGPB
                IF (PRH(N).GT.0.0) PRH0=PRH(N)/100.0
                IF (PRH0.GT.0.0) GO TO 1030
1020        CONTINUE
1030    DO 1040 N=1,NSEGPB
1040        PRH(N)=PRH(N)/PRH0
        DPRHT0=(PRH(1)-1.)/TAUPRH(1)
        GO TO 1230
1050    WRITE (6,1570) TITLE
        IF (FIRE.EQ.2) GO TO 1060
        WRITE (6,1590) TAULIM,Q0
        IF (LINTER) WRITE (6,2390)
        IF (LINTER) READ (5,1530) CHARTR
        CALL EXFIRE
        GO TO 1110
1060    WRITE (6,1610) TAULIM,Q0,HCOMB
        IF (LINTER) WRITE (6,2390)
        IF (LINTER) READ (5,1530) CHARTR
        DO 1070 N=1,NSEGB
            WRITE (6,1730) N,TAUQ(N),N,Q(N)
1070        CONTINUE
            IF (Q0.GT.0.0) GO TO 1090
            DO 1080 N=1,NSEGB
                IF (Q(N).GT.0.0) Q0=Q(N)/100.0
                IF (Q0.GT.0.0) GO TO 1090
1080        CONTINUE
1090    Q0=Q0*HCOMB
        DO 1100 N=1,NSEGB
            Q(N)=Q(N)*HCOMB/Q0
1100        DQD0=(Q(1)-1.)/TAUQ(1)
1110    IF (LINTER) WRITE (6,2390)
        IF (LINTER) READ (5,1530) CHARTR
        WRITE (6,1750) ALAMR,ALAMC,DELTA,DELTAM
        IF (NCND.EQ.0) PRD0=0.0
        IF (NCND.EQ.0) DPRDT0=0.0
        IF (NCND.EQ.0) GO TO 1170
        IF (PRODD.EQ.2) GO TO 1120
        WRITE (6,1640) BETAD
        PRD0=BETAD*Q0

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MAIN PROGRAM

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DPRDT0=DQDT0
GO TO 1170
1120 WRITE (6,1690) PRD0
DO 1130 N=1,NSEGPD
    WRITE (6,1710) N,TAUPRD(N),N,PRD(N)
1130 CONTINUE
    IF (PRD0.GT.0.0) GO TO 1150
DO 1140 N=1,NSEGPD
    IF (PRD(N).GT.0.0) PRD0=PRD(N)/100.0
    IF (PRD0.GT.0.0) GO TO 1150
1140 CONTINUE
1150 DO 1160 N=1,NSEGPD
1160 PRD(N)=PRD(N)/PRD0
DPRDT0=(PRD(1)-1.)/TAUPRD(1)
1170 IF (LINTER) WRITE (6,2390)
    IF (LINTER) READ (5,1530) CHARTR
    IF (PRODH.EQ.2) GO TO 1180
    WRITE (6,1650) BETAH
    PRH0=BETAH*Q0
    DPRHT0=DQDT0
    GO TO 1230
1180 WRITE (6,1700) PRH0
DO 1190 N=1,NSEGPH
    WRITE (6,1720) N,TAUPRH(N),N,PRH(N)
1190 CONTINUE
    IF (PRH0.GT.0.0) GO TO 1210
DO 1200 N=1,NSEGPH
    IF (PRH(N).GT.0.0) PRH0=PRH(N)/100.0
    IF (PRH0.GT.0.0) GO TO 1210
1200 CONTINUE
1210 DO 1220 N=1,NSEGPH
1220 PRH(N)=PRH(N)/PRH0
DPRHT0=(PRH(1)-1.)/TAUPRH(1)
1230 IF (LINTER) WRITE (6,2390)
    IF (LINTER) READ (5,1530) CHARTR
    IF (NCND.EQ.0) GO TO 1240
    NDET=NCND
    FLAG=1
    GO TO 1260
1240 IF (NTMD.EQ.0) GO TO 1250
    NDET=NTMD
    FLAG=2
    GO TO 1260
1250 IF (NRRD.EQ.0) GO TO 1500
    NDET=NRRD
    FLAG=3
C
C GO THROUGH NDET VALUES OF SPECIFIC UPPER LAYER DETECTION METHOD
C UNDER CONSIDERATION.
C
1260 DO 1490 I=1,NDET
C
C GO THROUGH NTMHU VALUES OF MINIMUM TEMPERATURES WHICH MAKE UPPER LAYER
C HAZARDOUS DUE TO RADIATION EVEN WHEN INTERFACE IS ABOVE ZEYEF.
C
    DO 1480 J=1,NTMHU
C
C GO THROUGH NTMHL VALUES OF MINIMUM TEMPERATURES WHICH MAKE UPPER

```

MAIN PROGRAM

C LAYER HAZARDOUS DUE TO DIRECT BURNS OR INHALING OF HOT GASES (I.E.,
C WHEN INTERFACE IS BELOW ZEYEF).

C

DO 1470 N=1,NTMHL

C

C GO THROUGH NCNH VALUES OF PRODUCT CONCENTRATIONS WHICH MAKE UPPER
C LAYER HAZARDOUS WHEN INTERFACE IS BELOW ZEYEF.

C

DO 1460 L=1,NCNH

C

C PRINT CRITERIA FOR DETECTION AND HAZARD.

C

```

1270      IF ((WRC.EQ.2).OR.(WRC.EQ.4)) GO TO 1300
          GO TO (1270,1280,1290), FLAG
          WRITE (6,1560) TITLE
          WRITE (6,1760) CNDS(I),ZEYEF,ZEYEM,TMHSUF(J),
2             TMHSUC(J),ZEYEF,ZEYEM,TMHSUF(N),TMHSLC(N),
3             CNHS(L)
          GO TO 1340
1280      WRITE (6,1560) TITLE
          WRITE (6,1780) TMDSPF(I),TMDSPC(I),ZEYEF,ZEYEM
2             ,TMHSUF(J),TMHSUC(J),ZEYEF,ZEYEM,TMHSUF(N),
3             TMHSLC(N),CNHS(L)
          GO TO 1340
1290      WRITE (6,1560) TITLE
          WRITE (6,1800) RRDSPF(I),RRDSPC(I),ZEYEF,ZEYEM
2             ,TMHSUF(J),TMHSUC(J),ZEYEF,ZEYEM,TMHSUF(N),
3             TMHSLC(N),CNHS(L)
          GO TO 1340
1300      GO TO (1310,1320,1330), FLAG
1310      WRITE (6,1570) TITLE
          WRITE (6,1770) CNDS(I),ZEYEF,ZEYEM,TMHSUF(J),
2             TMHSUC(J),ZEYEF,ZEYEM,TMHSUF(N),TMHSLC(N),
3             CNHS(L)
          GO TO 1340
1320      WRITE (6,1570) TITLE
          WRITE (6,1790) TMDSPF(I),TMDSPC(I),ZEYEF,ZEYEM
2             ,TMHSUF(J),TMHSUC(J),ZEYEF,ZEYEM,TMHSUF(N),
3             TMHSLC(N),CNHS(L)
          GO TO 1340
1330      WRITE (6,1570) TITLE
          WRITE (6,1810) RRDSPF(I),RRDSPC(I),ZEYEF,ZEYEM
2             ,TMHSUF(J),TMHSUC(J),ZEYEF,ZEYEM,TMHSUF(N),
3             TMHSLC(N),CNHS(L)

```

C

C GO THROUGH NH VALUES OF COMPARTMENT HEIGHTS.

C

```

1340      IF (LINTER) WRITE (6,2390)
          IF (LINTER) READ (5,1530) CHARTR
          DO 1450 K=1,NH
2             IF ((WRC.EQ.1).OR.(WRC.EQ.3))
                    WRITE (6,1820) HF(K),HM(K)
2             IF ((LINTER).AND.(WRC.EQ.1))
                    WRITE (6,2390)
2             IF ((LINTER).AND.(WRC.EQ.1))
                    READ (5,1530) CHARTR
          IF (WRC.EQ.1) WRITE (6,1560) TITLE
          IF ((WRC.EQ.1).AND.(LNORM))

```


MAIN PROGRAM

```

2          WRITE (6,1840)
          IF ((WRC.EQ.1).AND.(.NOT.(LNORM)))
2          WRITE (6,1850)
C
C  SET DIMENSIONLESS INITIAL VALUES AND HAZARD CRITERIA PARAMETERS
C  FOR FILLING PROBLEM.
C
          GO TO (1350,1360,1370), FLAG
1350      CNDSP=CNDS(I)
          GO TO 1380
1360      PHIDSP=(TMDSPF(I)+460.)/530.
          GO TO 1380
1370      DPHIDS=(RRDSPF(I)/31800.0)
1380      ZETEEY=ZEYEF
          ZETO=HF(K)-DELTA
          PHIHSU=(TMHSUF(J)+460.)/530.
          PHIHSL=(TMHSLF(N)+460.)/530.
          CNHAZS=CNHS(L)
          IDETH=1
          IDETT=1
          IDETR=1
          LIMIT=0
C
C  GO THROUGH ALL INPUT COMPARTMENT AREAS.
C
          DO 1440 M=1,NS
              IF ((WRC.EQ.2).OR.(WRC.EQ.4))
2              WRITE (6,1820) HF(K),HM(K)
              IF ((WRC.EQ.2).OR.(WRC.EQ.3).OR.
2              (WRC.EQ.4))
3              WRITE (6,1830) SF(M),SM(M)
              IF ((.NOT.(LINTER)).OR.(WRC.EQ.1))
2              GO TO 1390
              WRITE (6,2390)
              READ (5,1530) CHARTR
1390      C1=(1.-ALAMC)*0.1070*Q0/SF(M)
              C2=0.210*((32./(.0735*.24*530.*1.054
2              ))*(1./3.))
3              *(((1.-ALAMR)*Q0)
4              *(1./3.))/SF(M)
              C3D=0.02943*PRD0/SF(M)
              C3H=0.02943*PRH0/SF(M)
              GO TO (1400,1410,1420), FLAG
1400      IDETH=0
              GO TO 1430
1410      IDETT=0
              GO TO 1430
1420      IDETR=0
1430      ASF=SF(M)
              ASM=SM(M)
              AHF=HF(K)
C
C  CALL SUBROUTINE AINT TO
C  INTEGRATE EQN. FOR INTERFACE POSITION AND COMPUTE TIMES AND PARA-
C  METERS FOR DETECTION AND HAZARD. PRINT RESULTS AND GO ON TO THE
C  NEXT ROOM AREA.
C
          CALL AINT(IDETH,IDE TT,IDE TR,PHIHSU,

```


MAIN PROGRAM

PHIHL,CNHAZS,PHIDSP,
CNDSP,ZETEEY,DPHIDS,ASF,
ASM,AHF,WRC,TITLE)

```

C
C IF DIGITAL DATA IS BEING USED AND IF THE UPPER LIMIT OF THAT DATA
C HAS BEEN REACHED (LIMIT=1), BYPASS THE REMAINING COMPARTMENT
C AREAS FOR HEIGHT M AND GO TO THE NEXT COMPARTMENT HEIGHT

```

```

C
                                IF (LIMIT.EQ.1) GO TO 1450
1440                                CONTINUE
1450                                CONTINUE
1460                                CONTINUE
1470                                CONTINUE
1480                                CONTINUE
1490                                CONTINUE

```

```

GO TO (1240,1250,1500), FLAG
1500 WRITE (6,2420)
STOP 5

```

```

C
1510  FORMAT(' INSTRUCTIONS'/' TO ENTER DATA: TYPE IN REQUESTED VALUE OR
      2 VALUES (MULTIPLE VALUES'/' SEPARATED BY A COMMA OR BLANK), THEN P
      3RESS CARRIAGE RETURN.')
1520  FORMAT (20A4)
1530  FORMAT(A1)
1540  FORMAT(5X,'LAMDA R          = ',F5.3/5X,'LAMDA C          = ',F5.3/
      25X,'EYELEVEL HEIGHT = ',F7.3/5X,'FIRE HEIGHT          = ',F7.3)
1550  FORMAT(I1)
1560  FORMAT (1H1,20X,20A4/)
1570  FORMAT(1H1,20A4/)
1580  FORMAT (1H0,4X,'THE INTEGRATIONS WILL NOT BE CARRIED OUT BEYOND ',
      2F5.0,'SECONDS FOLLOWING IGNITION'/'4X,'THE FOLLOWING DESCRIBES THE
      3 TIME HISTORY OF THE MULTI-EXPONENTIAL FIRE GROWTH CURVE:'/'5X,
      4'Q(TIME=0.0) = Q0 = ',F8.2,' KW '//' )
1590  FORMAT(1H0,'THE INTEGRATIONS WILL NOT BE CARRIED OUT BEYOND ',F5.0
      2,' SECONDS'/' FOLLOWING IGNITION.'/' THE TIME HISTORY OF THE MULTI
      3-EXPONENTIAL FIRE GROWTH CURVE:'/'4X,'Q(TIME=0.0)=Q0=',F8.2,' KW' )
1600  FORMAT (1H0,'ADD AN ANALYTIC FIRE GROWTH FUNCTION')
1610  FORMAT (1H0,3X,'THE INTEGRATIONS WILL NOT BE CARRIED OUT BEYOND ',
      2F5.0,'SECONDS'/' FOLLOWING IGNITION.'/'3X,'THE FOLLOWING DATA CHAR
      3ACTERIZE THE HISTORY OF THE FIRE:'/'
      45X,'Q(TIME=0.0) = Q0 = ',F8.2,' KW '//'
      55X,'HCOMB = ',E12.4//)
1620  FORMAT('0THE DETECTABLE PRODUCT OF COMBUSTION GENERATION RATE IS P
      2ROPORTIONAL TO ENERGY GENERATION RATE ACCORDING TO:'/'20X,'RATE OF
      3 PRODUCT GENERATION = (',E12.4,' UNTS PER SECOND PER KW)*RATE OF E
      4NERGY GENERATION')
1630  FORMAT('0THE HAZARDOUS PRODUCT OF COMBUSTION GENERATION RATE IS PR
      2OPORTIONAL TO ENERGY GENERATION RATE ACCORDING TO:'/'20X,'RATE OF
      3PRODUCT GENERATION = (',E12.4,' UNTS PER SECOND PER KW)*RATE OF EN
      4ERGY GENERATION')
1640  FORMAT('0THE DETECTABLE PRODUCT OF COMBUSTION GENERATION RATE IS P
      2ROPORTIONAL TO'/' ENERGY GENERATION RATE ACCORDING TO:'/' RATE OF
      3PRODUCT GENERATION = (',E12.4,' UNTS/SEC/KW)*ENERGY GENERATION RAT
      4E')
1650  FORMAT('0THE HAZARDOUS PRODUCT OF COMBUSTION GENERATION RATE IS PR
      2OPORTIONAL TO'/' ENERGY GENERATION RATE ACCORDING TO:'/' RATE OF P
      3PRODUCT GENERATION = (',E12.4,' UNTS/SEC/KW)*ENERGY GENERATION RATE

```

MAIN PROGRAM

```

4')
1660  FORMAT (1H0,' ADD AN ANALYTIC PRODUCT GENERATION')
1670  FORMAT (1H0,3X,'THE FOLLOWING DATA CHARACTERIZE THE HISTORY OF'
2' THE DETECTABLE PRODUCT OF COMBUSTION GENERATION RATE: '//
35X,' P(TIME=0.0)=P0=',E10.4,' UNITS PER SECOND '//)
1680  FORMAT (1H0,3X,'THE FOLLOWING DATA CHARACTERIZE THE HISTORY OF'
2' THE HAZARDOUS PRODUCT OF COMBUSTION GENERATION RATE: '//
35X,' P(TIME=0.0)=P0=',E10.4,' UNITS PER SECOND '//)
1690  FORMAT('0 THE HISTORY OF THE DETECTABLE PRODUCT OF COMBUSTION GENE
2RATION RATE: '//5X,' P(TIME=0.0)=P0=',E10.4,' UNITS PER SECOND'//)
1700  FORMAT('0 THE HISTORY OF THE HAZARDOUS PRODUCT OF COMBUSTION GENER
2ATION RATE: '//5X,' P(TIME=0.0)=P0=',E10.4,' UNITS PER SECOND'//)
1710  FORMAT(1H,'TAUPRD('',I3,'') = ',F6.0,5X,'PRD('',I3,'') = ',E12.4)
1720  FORMAT(1H,'TAUPRH('',I3,'') = ',F6.0,5X,'PRH('',I3,'') = ',E12.4)
1730  FORMAT (1H,'TAUQ('',I3,'') = ',F6.0,5X,'Q('',I3,'') = ',E12.4)
1740  FORMAT (1H0,1X,'FRACTION OF FIRE ENERGY WHICH IS LOST TO WALLS AND
2 FLOOR BY RADIATION AND WHICH IS NOT EFFECTIVE IN DRIVING PLUME =
3',F5.3,/2X,'FRACTION OF FIRE ENERGY LOST TO ALL SURFACES = '
4,F5.3/
51H0,'THE FIRE IS LOCATED ',F7.3,' FEET ( ',F7.3,' METERS) ABOVE TH
6E FLOOR.')
1750  FORMAT(1H0,1X,'FRACTION OF FIRE ENERGY WHICH IS LOST TO WALLS AND
2FLOOR BY RADIATION'/' AND WHICH IS NOT EFFECTIVE IN DRIVING PLUME
3= ',F5.3/2X,'FRACTION OF FIRE ENERGY LOST TO ALL SURFACES = ',F5.3
4/1H0,'THE FIRE IS LOCATED ',F7.3,' FEET ( ',F7.3,' METERS) ABOVE T
5HE FLOOR.')
1760  FORMAT(1H0,' FIRE DETECTED WHEN DETECTABLE UPPER LAYER PRODUCT CON
2CENTRATION EXCEEDS',E10.4,' UNITS OF MASS PER UNIT MASS OF BULK UP
3PER LAYER GAS.'//
42X,' IF LAYER INTERFACE IS HIGHER THAN ',F6.2,' FT (',F6.2,' M) FR
50M FLOOR THEN '/2X,' HAZARDOUS CONDITIONS EXIST IF UPPER LAYER TEM
6PERATURE EXCEEDS ',F6.1,' DEG F (',F6.1,' DEGC)'/2X,' IF LAYER INT
7ERFACE IS AT OR BELOW ',F6.2,' FT (',F6.2,' M) FROM FLOOR THEN '/2
8X,' HAZARDOUS CONDITIONS EXIST IF UPPER LAYER TEMPERATURE EXCEEDS
9',F6.1,' DEG F (',F6.1,' DEG C)'/2X,'OR UPPER LAYER PRODUCT CONCEN
*TRATION EXCEEDS',E10.4,' UNITS OF MASS PER UNIT MASS OF BULK UPPER
1 LAYER GAS.'////)
1770  FORMAT(1H0,' FIRE DETECTED WHEN DETECTABLE UPPER LAYER PRODUCT CON
2CENTRATION EXCEEDS'/5X,E10.4,' UNITS OF MASS PER UNIT MASS OF BULK
3 UPPER LAYER GAS.'//
42X,' IF LAYER INTERFACE IS HIGHER THAN ',F6.2,' FT (',F6.2,' M) FR
50M FLOOR THEN '/2X,' HAZARDOUS CONDITIONS EXIST IF UPPER LAYER TEM
6PERATURE EXCEEDS ',F6.1,' DEG F.'/63X,'((',F6.1,' DEGC)'/2X,' IF LA
7YER INTERFACE IS AT OR BELOW ',F6.2,' FT (',F6.2,' M) FROM FLOOR T
8HEN '/2X,' HAZARDOUS CONDITIONS EXIST IF UPPER LAYER TEMPERATURE E
9XCEEDS ',F6.1,' DEG F.'/63X,'((',F6.1,' DEG C)'/2X,'OR UPPER LAYER
*PRODUCT CONCENTRATION EXCEEDS'/10X,E9.4,' UNITS OF MASS PER UNIT M
1ASS OF BULK UPPER LAYER GAS.')
1780  FORMAT (1H0,1X,'FIRE DETECTED WHEN UPPER LAYER TEMPERATURE IS ',F6
2.1,' DEG F (',F6.1,' DEG C).'/
32X,' IF LAYER INTERFACE IS HIGHER THAN ',F6.2,' FT (',F6.2,' M) FR
40M FLOOR THEN '/2X,' HAZARDOUS CONDITIONS EXIST IF UPPER LAYER TEM
5PERATURE EXCEEDS ',F6.1,'DEG F (',F6.1,' DEGC)'/2X,' IF LAYER INT
6ERFACE IS AT OR BELOW ',F6.2,' FT (',F6.2,' M) FROM FLOOR THEN '/2
7X,' HAZARDOUS CONDITIONS EXIST IF UPPER LAYER TEMPERATURE EXCEEDS
8',F6.1,' DEG F (',F6.1,' DEG C)'/2X,'OR UPPER LAYER PRODUCT CONCEN
9TRATION EXCEEDS',E9.4,' UNITS OF MASS PER UNIT MASS OF BULK UPPER
*LAYER GAS.'////)

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MAIN PROGRAM

```

1790  FORMAT (1H0,1X,'FIRE DETECTED WHEN UPPER LAYER TEMPERATURE IS ',F6
2.1,' DEG F'/62X, '('',F6.1,' DEG C).'/
32X,' IF LAYER INTERFACE IS HIGHER THAN ',F6.2,' FT (',F6.2,' M) FR
40M FLOOR THEN '/2X,' HAZARDOUS CONDITIONS EXIST IF UPPER LAYER TEM
5PERATURE EXCEEDS ',F6.1,' DEG F.'/63X, '('',F6.1,' DEGC)'/2X,' IF LA
6YER INTERFACE IS AT OR BELOW ',F6.2,' FT (',F6.2,' M) FROM FLOOR T
7HEN '/2X,' HAZARDOUS CONDITIONS EXIST IF UPPER LAYER TEMPERATURE E
8XCEEDS ',F6.1,' DEG F.'/63X, '('',F6.1,' DEG C)'/2X,'OR UPPER LAYER
9PRODUCT CONCENTRATION EXCEEDS'/10X,E9.4,' UNITS OF MASS PER UNIT M
*ASS OF BULK UPPER LAYER GAS.')
```

```

1800  FORMAT (1H0,1X,'FIRE DETECTED WHEN RATE OF TEMPERATURE RISE OF UP
2ER LAYER IS ',F6.2,' DEG F/MIN (',F6.2,' DEG C/MIN).'/
32X,' IF LAYER INTERFACE IS HIGHER THAN ',F6.2,' FT (',F6.2,' M) FR
40M FLOOR THEN '/2X,' HAZARDOUS CONDITIONS EXIST IF UPPER LAYER TEM
5PERATURE EXCEEDS ',F6.1,'DEG F (',F6.1,' DEGC).'/2X,' IF LAYER INT
6ERFACE IS AT OR BELOW ',F6.2,' FT (',F6.2,' M) FROM FLOOR THEN '/2
7X,' HAZARDOUS CONDITIONS EXIST IF UPPER LAYER TEMPERATURE EXCEEDS
8',F6.1,' DEG F (',F6.1,' DEG C)'/2X,'OR UPPER LAYER PRODUCT CONCEN
9TRATION EXCEEDS',E9.4,' UNITS OF MASS PER UNIT MASS OF BULK UPPER
*LAYER GAS.'//')
```

```

1810  FORMAT (1H0,1X,'FIRE DETECTED WHEN RATE OF TEMPERATURE RISE OF UP
2ER LAYER IS ',F6.2,' DEG F/MIN (',F6.2,' DEG C/MIN).'/
32X,' IF LAYER INTERFACE IS HIGHER THAN ',F6.2,' FT (',F6.2,' M) FR
40M FLOOR THEN '/2X,' HAZARDOUS CONDITIONS EXIST IF UPPER LAYER TEM
5PERATURE EXCEEDS ',F6.1,' DEG F.'/63X, '('',F6.1,' DEGC)'/2X,' IF LA
6YER INTERFACE IS AT OR BELOW ',F6.2,' FT (',F6.2,' M) FROM FLOOR T
7HEN '/2X,' HAZARDOUS CONDITIONS EXIST IF UPPER LAYER TEMPERATURE E
8XCEEDS ',F6.1,' DEG F.'/63X, '('',F6.1,' DEG C)'/2X,'OR UPPER LAYER
9PRODUCT CONCENTRATION EXCEEDS'/10X,E9.4,' UNITS OF MASS PER UNIT M
*ASS OF BULK UPPER LAYER GAS.')
```

```

1820  FORMAT(1H ///1H ,19H HEIGHT OF ROOM IS ,F6.2 , 5H FT (,F6.2 ,
25H M). /)
```

```

1830  FORMAT(' AREA OF ROOM IS ',F8.2,' FT**2 ( ',F8.2,' M**2)')
```

```

1840  FORMAT(1H0,31X,'LAYER      RATE OF',14X,'DETECTABLE',19X,'INTERFACE'
2,13X,'HAZARDOUS'/4X,'AREA      TIME      TEMP.  THICKNESS  RISE',
36X,'Q/Q0      CONCEN.      TIME      TEMP.  ELEVATION  Q/Q0',5X,'
4CONCEN.  AVAILABLE'/14X,'AT',7X,'AT',8X,'AT',9X,'AT',8X,'AT',9X,'A
5T',8X,'AT',7X,'AT',8X,'AT',9X,'AT',9X,'AT',6X,'EGRESS'/10X,'DETECT
6ION DETECTION DETECTION DETECTION DETECTION DETECTION DETECTION HAZARD
7HAZARD      HAZARD      HAZARD      HAZARD      TIME'//3X,'FT**2',6X,'S
8EC      DEG F',6X,'FT',6X,'DEGF/M',28X,'SEC      DEG F',6X,'FT',30X,
9'SEC'/3X,'(M**2)',12X,'(DEG C)      (M)      (DEGC/M)',33X,'(DEG C)
*      (M)'//')
```

```

1850  FORMAT(1H0,31X,'LAYER      RATE OF',14X,'DETECTABLE',19X,'INTERFACE'
2,13X,'HAZARDOUS'/4X,'AREA      TIME      TEMP.  THICKNESS  RISE',
36X,' Q      CONCEN.      TIME      TEMP.  ELEVATION  Q ',5X,'
4CONCEN.  AVAILABLE'/14X,'AT',7X,'AT',8X,'AT',9X,'AT',8X,'AT',9X,'A
5T',8X,'AT',7X,'AT',8X,'AT',9X,'AT',9X,'AT',6X,'EGRESS'/10X,'DETECT
6ION DETECTION DETECTION DETECTION DETECTION DETECTION DETECTION HAZARD
7HAZARD      HAZARD      HAZARD      HAZARD      TIME'//3X,'FT**2',6X,'S
8EC      DEG F',6X,'FT',6X,'DEGF/M',7X,'KW',19X,'SEC      DEG F',6X,'
9FT',10X,'KW',18X,'SEC'/3X,'(M**2)',12X,'(DEG C)      (M)      (DEGC/
*M)',33X,'(DEG C)      (M)'//')
```

```

1860  FORMAT(' WILL DATA BE ENTERED INTERACTIVELY (Y/N) ?')
```

```

1870  FORMAT(' PROGRAM WILL BE EXECUTED IN INTERACTIVE MODE.')
```

```

1880  FORMAT(' ENTER A RUN TITLE, UP TO 80 CHARACTERS LONG.')
```

```

1890  FORMAT(' ENTER CODE NUMBER OF THE DESIRED FORM OF OUTPUT:'/3X,
2'TYPE 1 FOR SUMMARY OUTPUT, 132 CHARACTERS PER LINE'/
```

MAIN PROGRAM

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3  8X,'2 FOR SUMMARY OUTPUT, 80 CHARACTERS PER LINE'/
4  8X,'3 FOR FULL OUTPUT, 132 CHARACTERS PER LINE'/
5  8X,'4 FOR FULL OUTPUT, 80 CHARACTERS PER LINE')
1900 FORMAT(' SUMMARY OUTPUT, 132 CHARACTERS PER LINE HAS BEEN SELECTED
2.')
1910 FORMAT(' SUMMARY OUTPUT, 80 CHARACTERS PER LINE HAS BEEN SELECTED.
2')
1920 FORMAT(' FULL OUTPUT, 132 CHARACTERS PER LINE HAS BEEN SELECTED.')
1930 FORMAT(' FULL OUTPUT, 80 CHARACTERS PER LINE HAS BEEN SELECTED.')
1940 FORMAT(/10X,'IS THIS CORRECT (Y/N) ?')
1950 FORMAT(' ENTER: 1. LAMDA R,'/8X,'2. LAMDA C,'/8X,'3. EYELEVEL HEIG
2HT, IN FEET, AND'/8X,'4. FIRE HEIGHT, IN FEET.'/
3' DO YOU NEED MORE INFORMATION (Y/N) ?')
1960 FORMAT('0 *** LAMDA R - THE FRACTION OF THE ENERGY GENERATION RATE
2 INSTANTANEOUSLY ***'/ ' ***',11X,'LOST BY RADIATION FROM THE COMB
3USTION ZONE AND PLUME.',6X,'****'/ ' *** LAMDA C - THE FRACTION OF
4THE ENERGY GENERATION RATE LOST TO THE ***'/ ' ***',11X,'BOUND
5ING SURFACES OF THE ROOM AND ITS CONTENTS.',12X,'****'/
6' *** EYELEVEL HEIGHT - THE SPECIFIED CHARACTERISTIC HEIGHT, IN F
7FEET, OF ***'/ ' ***',19X,'EYELEVEL FROM THE FLOOR.',27X,'****'/
8' *** FIRE HEIGHT - THE HEIGHT, IN FEET, OF THE BASE OF THE FIRE
9ABOVE ***'/ ' ***',15X,'THE FLOOR.',45X,'****')
1970 FORMAT(' >>ENTER THE REQUESTED VALUES.<<')
1980 FORMAT(' DATA WILL BE ENTERED IN THE FOLLOWING ORDER:.'/ ' I. DETE
2TION CRITERIA IV. FIRE DATA'/ ' II. HAZARD CRITERIA V
3. PRODUCTS OF COMBUSTION DATA'/ ' III. ROOM SIZES')
1990 FORMAT(26X,'I. DETECTION CRITERIA')
2000 FORMAT(' ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F (DETECTION)
2'/ ' TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO DETECTION BY RA
3TE OF RISE.')
2010 FORMAT(' ENTER A RATE OF LAYER TEMPERATURE RISE, IN DEGREES F/MIN
2(DETECTION).'/7X,'***'(TYPE 0.0 FOR INSTANTANEOUS DETECTION.)***'/
3 TYPE AN END OF FILE (UNIVAC: @EOF) TO MOVE TO DETECTION BY CONCEN
4TRATION.')
2020 FORMAT(3X,'***INSTANTANEOUS DETECTION***')
2030 FORMAT(' ENTER A CONCENTRATION OF A PRODUCT OF COMBUSTION,.'/ ' IN P
2RODUCT UNITS/GRAM OF BULK GAS (DETECTION).'/ ' TYPE AN END OF FILE
3 (UNIVAC: @EOF) TO MOVE TO HAZARD CRITERIA DATA INPUT.')
2040 FORMAT(26X,'II. HAZARD CRITERIA')
2050 FORMAT(' ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F'/ ' (INTE
2RFACE ABOVE SPECIFIED EYELEVEL) (HAZARD).'/ ' TYPE AN END OF FILE
3(UNIVAC: @EOF) TO MOVE TO HAZARD'/ ' BY LAYER TEMPERATURE, WHEN INT
4ERFACE BELOW EYELEVEL.')
2060 FORMAT(' ENTER A SMOKE LAYER TEMPERATURE, IN DEGREES F'/ ' (INTE
2RFACE BELOW SPECIFIED EYELEVEL) (HAZARD).'/ ' TYPE AN END OF FILE
3(UNIVAC: @EOF) TO MOVE TO HAZARD BY POC CONCENTRATION.')
2070 FORMAT(' ENTER A CONCENTRATION OF A PRODUCT OF COMBUSTION,.'/ ' IN P
2RODUCT UNITS/GRAM OF BULK GAS (HAZARD).'/ ' TYPE AN END OF FILE (U
3NIVAC: @EOF) TO MOVE TO ROOM SIZE DATA INPUT.')
2080 FORMAT(26X,'III. ROOM SIZE DATA')
2090 FORMAT(' ENTER A COMPARTMENT CEILING HEIGHT, IN FEET.'/ ' TYPE AN
2END OF FILE (UNIVAC: @EOF) TO MOVE TO COMPARTMENT AREA INPUT.')
2100 FORMAT(' ENTER A COMPARTMENT FLOOR AREA, IN SQUARE FEET.'/ ' TYPE
2AN END OF FILE (UNIVAC: @EOF) TO MOVE TO FIRE DATA INPUT.')
2110 FORMAT(29X,'IV. FIRE DATA')
2120 FORMAT(' SELECT THE REPRESENTATIVE FORM OF FIRE ENERGY GENERATION
2RATE.'/4X,
3'TYPE 1 FOR AN EXPONENTIAL FIRE GROWTH CURVE.'/

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MAIN PROGRAM

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4  9X,'2 FOR DIGITAL DATA INPUT.')
```

2130 FORMAT(' AN EXPONENTIAL FIRE GROWTH CURVE HAS BEEN SELECTED.')

2140 FORMAT(' DIGITAL DATA INPUT HAS BEEN SELECTED.')

2150 FORMAT(' GENERAL FORM: $Q = Q_1 * \exp(\alpha(T-T_1))$.'/

2' ENTER THE MAXIMUM TIME, IN SECONDS, FOR WHICH THE FIRE WILL BE M
3ODELED.')

2160 FORMAT(' ENTER: 1. THE ENERGY GENERATION RATE (Q1), IN KILOWATTS,
2'//11X,'AT THE BEGINNING OF EACH TIME SEGMENT, AND'/

38X,'2. THE ENERGY GENERATION RATE EXPONENTIAL FACTOR (ALPHA),'/11X
4,'IN UNITS OF 1/SECOND, FOR THAT TIME SEGMENT.'//

5' ENTER ONE PAIR FOR EACH TIME SEGMENT IN THE CURVE.'/ ' ENTER THEM
(ONE AT A TIME.'/ ' WHEN ALL HAVE BEEN ENTERED, TYPE AN END OF FILE

7 (UNIVAC: @EOF).')

2170 FORMAT(5X,I3,') Q = ',F8.2,' EXP(',F7.4,'(T-T1))'.'/)

2180 FORMAT(' DO YOU WANT FIRE ENERGY GENERATION RATE DATA'/' PRESEN
2TED IN NORMALIZED FORM, $Q(T)/Q(1)$ (Y/N) ?')

2190 FORMAT(' THE FIRE DATA OUTPUT WILL BE NORMALIZED.')

2200 FORMAT(' THE FIRE DATA OUTPUT WILL NOT BE NORMALIZED.')

2210 FORMAT(' ENTER: 1. THE MAXIMUM TIME, IN SECONDS, FOR WHICH THE FIR
2E WILL BE MODELED,'/11X,'AND'/8X,'2. THE HEAT OF COMBUSTION, IN KJ
3/KG.')

2220 FORMAT(5X,'MAXIMUM TIME = ',F5.0/5X,'HEAT OF COMBUSTION = ',
2F12.4)

2230 FORMAT(' ENTER THE INITIAL ENERGY GENERATION RATE.')

2240 FORMAT(5X,'Q0 = ',F8.2)

2250 FORMAT(' ENTER THE REST OF THE DIGITAL DATA POINTS ONE AT A TIME.
2'/' EACH DATA POINT SHOULD CONSIST OF A TIME, IN SECONDS,'/' AND A
3 CORRESPONDING ENERGY GENERATION RATE.'/' WHEN ALL HAVE BEEN ENTER
4ED, TYPE AN END OF FILE (UNIVAC: @EOF).')

2260 FORMAT(' DO YOU WANT FIRE ENERGY GENERATION RATE DATA'/' PRESEN
2TED IN NORMALIZED FORM, $Q(T)/Q_0$ (Y/N) ?')

2270 FORMAT(20X,'V.1. DETECTABLE PRODUCT OF COMBUSTION DATA')

2280 FORMAT(' SELECT THE REPRESENTATIVE FORM OF PRODUCT GENERATION RATE
2.'/5X,
3'TYPE 1 FOR A METHOD USING A CONSTANT OF PROPORTIONALITY (BETA).'/

410X,'2 FOR DIGITAL DATA INPUT.')

2290 FORMAT(' A METHOD USING A CONSTANT OF PROPORTIONALITY HAS BEEN SEL
2ECTED.')

2300 FORMAT(' DIGITAL DATA INPUT HAS BEEN SELECTED.')

2310 FORMAT(' ENTER BETAD,'/' IN PRODUCT UNITS PER SEC PER KW OF FIRE E
2NERGY GENERATION RATE.'/5X,'PRODUCT GENERATION RATE = BETAD * ENER
3GY GENERATION RATE.')

2320 FORMAT(' ENTER BETAH,'/' IN PRODUCT UNITS PER SEC PER KW OF FIRE E
2NERGY GENERATION RATE.'/5X,'PRODUCT GENERATION RATE = BETAH * ENER
3GY GENERATION RATE.')

2330 FORMAT(20X,'V.2. HAZARDOUS PRODUCT OF COMBUSTION DATA')

2340 FORMAT(' ENTER THE INITIAL DETECTABLE PRODUCT GENERATION RATE.')

2350 FORMAT(' ENTER THE REST OF THE DIGITAL DATA POINTS ONE AT A TIME.
2'/' EACH DATA POINT SHOULD CONSIST OF A TIME, IN SECONDS, AND'/' A
3 CORRESPONDING DETECTABLE PRODUCT GENERATION RATE.'/' WHEN ALL HAV
4E BEEN ENTERED, TYPE AN END OF FILE (UNIVAC: @EOF).')

2360 FORMAT(' ENTER THE INITIAL HAZARDOUS PRODUCT GENERATION RATE.')

2370 FORMAT(' ENTER THE REST OF THE DIGITAL DATA POINTS ONE AT A TIME.
2'/' EACH DATA POINT SHOULD CONSIST OF A TIME, IN SECONDS, AND'/' A
3 CORRESPONDING HAZARDOUS PRODUCT GENERATION RATE.'/' WHEN ALL HAVE
4 BEEN ENTERED, TYPE AN END OF FILE (UNIVAC: @EOF).')

2380 FORMAT(4X,'*** SINCE THERE WERE NO DETECTABLE CONCENTRATIONS SPECI
2FIED, ***'/4X,'*** DATA DESCRIBING THE GENERATION OF A DETECTABLE

MAIN PROGRAM

```

3 PRODUCT    ***'/4X,'*** OF COMBUSTION WILL NOT BE REQUIRED.',23X,
4 '***')
2390  FORMAT('0 PRESS CARRIAGE RETURN TO CONTINUE.')
2400  FORMAT('0*****
2*****')
2410  FORMAT('0-----
2-----')
2420  FORMAT('0 ****> PROGRAM EXECUTION COMPLETED <****')
2430  FORMAT('  *** THIS PROGRAM WILL CALCULATE THE AVAILABLE SAFE EGRES
2S TIME    ***'/ '  *** FROM A ROOM.',48X,'***'/ '  ***',63X,'***'/
3'  *** DOCUMENTATION: NBSIR 82-2578 BY LEONARD Y. COOPER AND',9X,
4'***'/ '  ***',33X,'DAVID W. STROUP',15X,'***')
2440  FORMAT('  ==> INCORRECT INPUT - TRY AGAIN <==')
2450  FORMAT('  ==> INPUT ERROR - RUN TERMINATED <==')
C
      END

```

SUBROUTINE EXFIRE

C THIS IS FGRESS*ASET.EXFIRE

C
C*****
C THIS SUBROUTINE USES THE APPROPRIATE INPUT DATA TO CHARACTERIZE
C THE MULTI-EXPONENTIAL FIRE GROWTH CURVE FOR USE
C IN FUNQ BY COMPUTING THE TAUQ(N) FROM THE AKAP(N) AND THE Q(N).
C THE SUBROUTINE ALSO PRINTS A DESCRIPTION OF THE ENERGY
C GENERATION RATE HISTORY.
C*****

C
C SUBROUTINE EXFIRE
C
C *****
C
COMMON NSEGQ,NSEGP,D,NSEGP,H,TAUQ(100),TAUPRD(100),TAUPRH(100),
2 Q(100),PRD(100),PRH(100),AKAP(100),C1,C2,C3D,C3H,ZETO,FIRE,
3 PRODD,PRODH,LIMIT,DPHI,TAULIM,LINTER,DELTA,DQDQTO,DPRDQTO,
4 DPRHTO,QO,LNORM
LOGICAL LINTER,LNORM
IF (.NOT.(LNORM)) GO TO 50

C
C THIS SECTION CALCULATES TAUQ(N) FOR NORMALIZED FIRE DATA.

C
IF (NSEGQ.GT.1) GO TO 10
WRITE (6,100) AKAP(1)
RETURN
10 NSEGM1=NSEGQ-1
TAUQ(1)=ALOG(Q(1))/AKAP(1)
IF (NSEGQ.GT.2) GO TO 20
WRITE (6,110) AKAP(1),TAUQ(1),Q(1)
WRITE (6,120) Q(1),AKAP(2),TAUQ(1),TAUQ(1),Q(1)
RETURN
20 DO 30 N=2,NSEGM1
TAUQ(N)=ALOG(Q(N)/Q(N-1))/AKAP(N)+TAUQ(N-1)
30 CONTINUE
WRITE (6,110) AKAP(1),TAUQ(1),Q(1)
NSEGM2=NSEGQ-2
DO 40 N=1,NSEGM2
WRITE (6,130) Q(N),AKAP(N+1),TAUQ(N),TAUQ(N),TAUQ(N+1),Q(N),Q
2 (N+1)
40 CONTINUE
WRITE (6,120) Q(NSEGM1),AKAP(NSEGQ),TAUQ(NSEGM1),TAUQ(NSEGM1),Q(NS
2 EGM1)
RETURN

C
C THIS SECTION CALCULATES TAUQ(N) FOR UN-NORMALIZED FIRE DATA.

C
50 IF (NSEGQ.GT.1) GO TO 60
WRITE (6,140) QO,AKAP(1)
RETURN
60 NSEGM1=NSEGQ-1
TAUQ(1)=ALOG(Q(1))/AKAP(1)
IF (NSEGQ.GT.2) GO TO 70
WQ1=Q(1)*QO
WRITE (6,150) QO,AKAP(1),TAUQ(1),QO,WQ1
WRITE (6,160) WQ1,AKAP(2),TAUQ(1),TAUQ(1),WQ1

SUBROUTINE EXFIRE

```

RETURN
70 DO 80 N=2,NSEGM1
    TAUG(N)=ALOG(Q(N)/Q(N-1))/AKAP(N)+TAUG(N-1)
80 CONTINUE
WQ1=Q(1)*Q0
WRITE (6,150) Q0,AKAP(1),TAUG(1),Q0,WQ1
NSEGM2=NSEGQ-2
DO 90 N=1,NSEGM2
    WQN=Q(N)*Q0
    WGN1=Q(N+1)*Q0
    WRITE (6,170) WQN,AKAP(N+1),TAUG(N),TAUG(N),TAUG(N+1),WQN,WQN
2      1
90 CONTINUE
WQL=Q(NSEGM1)
WRITE (6,160) WQL,AKAP(NSEGQ),TAUG(NSEGM1),TAUG(NSEGM1),WQL
RETURN
C
C
100 FORMAT (1H0,5X,'Q/Q0 = EXP(',F5.4,' * TIME/SEC) IF 0.0 < TIME/SEC'
2)
110 FORMAT(1H0,5X,'Q/Q0 = ',9X,'EXP(',F5.4,' * (TIME/SEC))'/' IF 0.
20 < TIME/SEC < ',F6.1,', THAT IS, IF ',3X,'1.0 < Q/Q0 < ',F6.0)
120 FORMAT(1H0,5X,'Q/Q0 = ',F6.0,' * EXP(',F5.4,' * (TIME/SEC - ',F6.1
2,'))'/' IF ',F6.1,' < TIME/SEC',9X,', THAT IS, IF ',F6.0,' < Q/Q0'
3)
130 FORMAT(1H0,5X,'Q/Q0 = ',F6.0,' * EXP(',F5.4,' * (TIME/SEC - ',F6.1
2,'))'/' IF ',F6.1,' < TIME/SEC < ',F6.1,', THAT IS, IF ',F6.0,' <
3Q/Q0 < ',F6.0)
140 FORMAT(1H0,5X,'Q = ',F6.0,' * EXP(',F5.4,' * TIME) IF 0.0 < TIME')
150 FORMAT(1H0,5X,'Q = ',F6.0,' * EXP(',F5.4,' * (TIME))'/' IF 0.0 < T
2IME < ',F6.1,', THAT IS, IF ',F6.0,' < Q < ',F6.0)
160 FORMAT(1H0,5X,'Q = ',F6.0,' * EXP(',F5.4,' * (TIME - ',F6.1,'))'/'
2' IF ',F6.1,' < TIME',9X,', THAT IS, IF ',F6.0,' < Q')
170 FORMAT(1H0,5X,'Q = ',F6.0,' * EXP(',F5.4,' * (TIME - ',F6.1,'))'/'
2' IF ',F6.1,' < TIME < ',F6.1,', THAT IS, IF ',F6.0,' < Q < ',F6.0
3)
C
END

```


SUBROUTINE FUNQ

```

C THIS IS EGRESS*ASET.FUNQ
C
C*****
C THIS IS FUNQ. IT COMPUTES:
C
C      QDQ0(T) = ENERGY GENERATION RATE AT TIME TAU=T / Q0
C*****
C
C      FUNCTION QDQ0 (T)
C
C      *****
C
C      INTEGER FIRE
C      COMMON NSEGG,NSEGGPD,NSEGGPH,TAUQ(100),TAUPRD(100),TAUPRH(100),
2          Q(100),PRD(100),PRH(100),AKAP(100),C1,C2,C3D,C3H,ZETO,FIRE,
3          PRODD,PRODH,LIMIT,DPHI,TAULIM,LINTER,DELTA,DQD0,DPRD0,
4          DPRHT0,Q0,LNORM
C      LOGICAL LINTER,LNORM
C      GO TO (10,60,90), FIRE
C
C THE FOLLOWING SEGMENT OF FUNQ IS USED TO COMPUTE QDQ0(T) FOR A
C MULTI-EXPONENTIAL FIRE GROWTH CURVE.
C
10      IF (T.EQ.0.) QDQ0=1.
        IF (T.EQ.0.) RETURN
        IF (NSEGG.EQ.1) GO TO 20
        IF (T.GE.TAUQ(1)) GO TO 30
20      QDQ0=EXP(AKAP(1)*T)
        RETURN
30      IF (NSEGG.EQ.2) GO TO 50
        NSEGM2=NSEGG-2
        DO 40 N=1,NSEGM2
            IF (T.GE.TAUQ(N+1)) GO TO 40
            QDQ0=Q(N)*EXP(AKAP(N+1)*(T-TAUQ(N)))
            RETURN
40      CONTINUE
50      QDQ0=Q(NSEGG-1)*EXP(AKAP(NSEGG)*(T-TAUQ(NSEGG-1)))
        RETURN
C
C THE FOLLOWING SEGMENT OF FUNQ IS USED TO COMPUTE QDQ0(T) FOR DIGITAL
C DATA AND LINEAR INTERPOLATION.
C
60      IF (T.EQ.0.) QDQ0=1.
        IF (T.EQ.0.) RETURN
        IF (T.GT.TAUQ(1)) GO TO 70
        QDQ0=Q(1)-((Q(1)-1.)/TAUQ(1))*(TAUQ(1)-T)
        RETURN
70      DO 80 N=1,NSEGG
            IF (T.GT.TAUQ(N)) GO TO 80
            QDQ0=Q(N)-((Q(N)-Q(N-1))/(TAUQ(N)-TAUQ(N-1)))*(TAUQ(N)-T)
            RETURN
80      CONTINUE
90      RETURN
END

```

SUBROUTINE FUNPRD

```

C THIS IS FGRESS*ASET.FUNPRD
C
C*****
C THIS IS FUNPRD. IT COMPUTES
C
C      PRDPRO(T) = PRODUCT GENERATION RATE AT TIME TAU=T /PRD0
C*****
C
C      FUNCTION PRDPRO (T)
C
C      *****
C
C      INTEGER PRODD
C      COMMON NSEGQ,NSEGPD,NSEGPB,TAUQ(100),TAUPRD(100),TAUPRH(100),
2          Q(100),PRD(100),PRH(100),AKAP(100),C1,C2,C3D,C3H,ZET0,FIRE,
3          PRODD,PRODH,LIMIT,DPHI,TAULIM,LINTER,DELTA,DQDT0,DPRDT0,
4          DPRHT0,Q0,LNORM
C      EXTERNAL QDQ0
C      LOGICAL LINTER,LNORM
C      GO TO (10,20,50), PRODD
C
C THE FOLLOWING SEGMENT OF FUNPRD IS USED TO COMPUTE PRDPRO(T) FOR A
C CASE WHERE THERE IS A CONSTANT OF PROPORTIONALITY BETWEEN PRODUCT
C GENERATION RATE AND ENERGY GENERATION RATE. THIS CONSTANT, BETAD,
C IS DEFINED AS
C
C      PRODUCT GENERATION RATE = BETAD * (ENERGY GENERATION RATE).
C
C IN THIS CASE, PRODD=1.
C
10      PRDPRO=QDQ0(T)
      RETURN
C
C THE FOLLOWING SEGMENT OF FUNPRD IS USED TO COMPUTE PRDPRO(T) FOR A
C CASE WHERE PRODUCT GENERATION RATE IS GIVEN BY LINEAR INTERPOLATION
C BETWEEN DIGITAL DATA POINTS. IN THIS CASE PRODD=2.
C
20      IF (T.EQ.0.) PRDPRO=1.
      IF (T.EQ.0.) RETURN
      IF (T.GT.TAUPRD(1)) GO TO 30
      PRDPRO=PRD(1)-((PRD(1)-1.)/TAUPRD(1))*(TAUPRD(1)-T)
      RETURN
30      DO 40 N=1,NSEGPB
          IF (T.GT.TAUPRD(N)) GO TO 40
          PRDPRO=PRD(N)-((PRD(N)-PRD(N-1))/(TAUPRD(N)-TAUPRD(N-1)))*(TA
2          UPRD(N)-T)
          RETURN
40      CONTINUE
50      RETURN
      END

```

SUBROUTINE FUNPRH

```

C THIS IS EGRESS*ASET.FUNPRH
C
C*****
C THIS IS FUNPRH. IT COMPUTES
C
C      PRHPR0(T) = PRODUCT GENERATION RATE AT TIME TAU=T /PRH0
C*****
C
C      FUNCTION PRHPR0 (T)
C
C      *****
C
C      INTEGER PRODH
C      COMMON NSEGQ,NSEGP0,NSEGP1,TAUQ(100),TAUPR0(100),TAUPRH(100),
2          G(100),PRD(100),PRH(100),AKAP(100),C1,C2,C3D,C3H,ZET0,FIRE,
3          PRODD,PRODH,LIMIT,DPHI,TAULIM,LINTER,DELTA,DQDT0,DPRDT0,
4          DPRHT0,Q0,LNORM
C      EXTERNAL QDQ0
C      LOGICAL LINTER,LNORM
C      GO TO (10,20,50), PRODH
C
C THE FOLLOWING SEGMENT OF FUNPRH IS USED TO COMPUTE PRHPR0(T) FOR A
C CASE WHERE THERE IS A CONSTANT OF PROPORTIONALITY BETWEEN PRODUCT
C GENERATION RATE AND ENERGY GENERATION RATE. THIS CONSTANT, BETAH,
C IS DEFINED AS
C
C      PRODUCT GENERATION RATE = BETAH * (ENERGY GENERATION RATE).
C
C IN THIS CASE, PRODH=1.
C
10      PRHPR0=QDQ0(T)
      RETURN
C
C THE FOLLOWING SEGMENT OF FUNPRH IS USED TO COMPUTE PRHPR0(T) FOR A
C CASE WHERE PRODUCT GENERATION RATE IS GIVEN BY LINEAR INTERPOLATION
C BETWEEN DIGITAL DATA POINTS. IN THIS CASE PRODH=2.
C
20      IF (T.EQ.0.) PRHPR0=1.
      IF (T.EQ.0.) RETURN
      IF (T.GT.TAUPRH(1)) GO TO 30
      PRHPR0=PRH(1)-((PRH(1)-1.)/TAUPRH(1))*(TAUPRH(1)-T)
      RETURN
30      DO 40 N=1,NSEGP1
          IF (T.GT.TAUPRH(N)) GO TO 40
          PRHPR0=PRH(N)-((PRH(N)-PRH(N-1))/(TAUPRH(N)-TAUPRH(N-1)))*(TA
2          UPRH(N)-T)
          RETURN
40      CONTINUE
50      RETURN
      END

```


SUBROUTINE SUBAINT

```

C THIS IS EGRESS*ASET.SUBAINT. IT REQUIRES EGRESS*ASET.SUBF AND INTGR.
C
C*****
C THIS SUBROUTINE SETS UP THE NUMERICAL INTEGRATION FOR OBTAINING THE
C INTERFACE POSITION AS IT DROPS FROM THE CEILING. THE HISTORY OF
C TEMPERATURE AND PRODUCT CONCENTRATION IN THE UPPER LAYER ARE ALSO
C COMPUTED. THE INTEGRATION IS DONE IN SPECIFIED TIME INTERVALS. AFTER
C EACH INTERVAL, CRITERIA FOR DETECTION AND HAZARD ARE EVALUATED. LINEAR
C INTERPOLATION WITHIN THESE INTERVALS ARE USED TO OBTAIN TIME AND
C PARAMETER VALUES FOR DETECTION AND HAZARD.
C*****
C
C                     NOTATION
C
C*****
C AQDQO    Q/QO AT END OF TIME STEP.
C CNDETD   DETECTABLE PRODUCT CONCENTRATION AT TIME OF DETECTION.
C CNDETH   HAZARDOUS PRODUCT CONCENTRATION AT TIME OF DETECTION.
C CNDSP    DIMENSIONLESS SPECIFIED DETECTABLE PRODUCT CONCENTRATION
C          FOR DETECTION.
C CNHAZD   DETECTABLE PRODUCT CONCENTRATION AT TIME OF HAZARD.
C CNHAZH   HAZARDOUS PRODUCT CONCENTRATION AT TIME OF HAZARD.
C CND      DETECTABLE PRODUCT CONCENTRATION OF UPPER LAYER AT END OF TIME
C          STEP.
C CNH      HAZARDOUS PRODUCT CONCENTRATION OF UPPER LAYER AT END OF TIME
C          STEP.
C CNHTST   A TEST VALUE FOR HAZARDOUS CONCENTRATION.
C CND0     INITIAL DETECTABLE PRODUCT CONCENTRATION OF UPPER LAYER.
C CND1
C CND2
C CNH0     INITIAL HAZARDOUS PRODUCT CONCENTRATION OF UPPER LAYER.
C CNH1
C CNH2
C DELTA    THE HEIGHT OF THE FIRE ABOVE THE FLOOR IN FEET.
C DELTAM   THE HEIGHT OF THE FIRE ABOVE THE FLOOR IN METERS.
C OPHI     DIMENSIONLESS RATE OF TEMPERATURE RISE OF UPPER LAYER,
C          DPHI/DTAU, GENERATED IN SUBF DURING THE COURSE OF THE INTEGRA-
C          TION.
C DPHID    DIMENSIONLESS RATE OF TEMPERATURE RISE OF UPPER LAYER AT
C          TIME OF DETECTION.
C DPHIDS   DIMENSIONLESS RATE OF TEMPERATURE RISE OF UPPER LAYER FOR
C          DETECTION SPECIFIED.
C DPHI0    INITIAL DIMENSIONLESS RATE OF TEMPERATURE RISE OF UPPER LAYER.
C DPHI1
C DPHI2
C DZDETf   UPPER LAYER THICKNESS AT TIME OF DETECTION IN FEET.
C DZDETM   UPPER LAYER THICKNESS AT TIME OF DETECTION IN METERS.
C DZF      UPPER LAYER THICKNESS AFTER EACH TIME INTERVAL IN FEET.
C DZM      UPPER LAYER THICKNESS AFTER EACH TIME INTERVAL IN METERS.
C HF       HEIGHT OF COMPARTMENT UNDER CONSIDERATION IN FEET.
C ITMEGS   TIME AVAILABLE FOR SAFE EGRESS, IN SECONDS.
C PHIDET   DIMENSIONLESS UPPER LAYER TEMP AT TIME OF DETECTION.
C PHIDSP   DIMENSIONLESS UPPER LAYER TEMP FOR DETECTION SPECIFIED.
C PHIHAZ   DIMENSIONLESS UPPER LAYER TEMP AT TIME OF HAZARD.
C PHIHSU   DIMENSIONLESS SPECIFIED UPPER LAYER TEMPERATURE WHEN INTERFACE

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SUBROUTINE SUBAINT

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C      IS ABOVE ZETEYE.
C PHIHSL DIMENSIONLESS SPECIFIED UPPER LAYER TEMPERATURE WHEN INTERFACE
C      IS BELOW ZETEYE.
C PHITST A TEST VALUE FOR PHI.
C PHI0   INITIAL UPPER LAYER TEMPERATURE.
C PHI1
C PHI2
C QDETQ0 Q AT THE TIME OF DETECTION / Q0
C QHAZQ0 Q AT THE TIME OF HAZARD / Q0
C RRC    RATE OF TEMPERATURE RISE OF UPPER LAYER IN DEGREES C PER
C        MINUTE AT END OF TIME STEP.
C RRDETC RATE OF TEMP RISE OF UPPER LAYER AT TIME OF DETECTION IN
C        DEGREES C PER MINUTE.
C RRDETF RATE OF TEMP RISE OF UPPER LAYER AT TIME OF DETECTION IN
C        DEGREES F PER MINUTE.
C RRF    RATE OF TEMPERATURE RISE OF UPPER LAYER IN DEGREES F PER
C        MINUTE AT END OF TIME STEP.
C TAUDET DIMENSIONLESS TIME AT TIME OF DETECTION.
C TAUHAZ DIMENSIONLESS TIME AT TIME OF HAZARD.
C TAU1   DIMENSIONLESS TIME AT LOWER LIMIT OF INTEGRATION.
C TAU2   DIMENSIONLESS TIME AT UPPER LIMIT OF INTEGRATION.
C TAUTSC A TEST VALUE FOR TAU.
C TAUTSP A TEST VALUE FOR TAU.
C TAUTST A TEST VALUE FOR TAU.
C TIMDS  TIME REQUIRED FOR DETECTION IN SECONDS.
C TIMHS  TIME TO REACH HAZARD IN SECONDS.
C TMC    LAYER TEMPERATURE AT END OF TIME STEP IN DEGREES C.
C TMDETC UPPER LAYER TEMP AT TIME OF DETECTION IN DEGREES C.
C TMDETF UPPER LAYER TEMP AT TIME OF DETECTION IN DEGREES F.
C TMF    LAYER TEMPERATURE AT END OF TIME STEP IN DEGREES F.
C TMHAZC UPPER LAYER TEMP AT TIME OF HAZARD IN DEGREES C.
C TMHAZF UPPER LAYER TEMP AT TIME OF HAZARD IN DEGREES F.
C SF     COMPARTMENT AREA UNDER CONSIDERATION IN SQUARE FEET.
C SM     COMPARTMENT AREA UNDER CONSIDERATION IN SQUARE METERS.
C UAQDQ0 Q AT END OF TIME STEP.
C UQDQDQ Q AT THE TIME OF DETECTION.
C UQHSDQ Q AT THE TIME OF HAZARD.
C ZETDET DIMENSIONLESS LAYER INTERFACE ELEVATION AT TIME OF DETECTION.
C ZETEYE DIMENSIONLESS ELEVATION OF EYELEVEL.
C ZETHAZ DIMENSIONLESS LAYER INTERFACE ELEVATION AT TIME OF HAZARD.
C ZHAZF  LAYER INTERFACE ELEVATION AT TIME OF HAZARD IN FEET.
C ZHAZM  LAYER INTERFACE ELEVATION AT TIME OF HAZARD IN METERS.
C ZF     LAYER ELEVATION AT END OF TIME STEP IN FEET .
C ZM     LAYER ELEVATION AT END OF TIME STEP IN METERS.

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C Z1
C Z2

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C*****'*****

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C

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      SUBROUTINE AINT (IDETH,IDETT,IDETR,PHIHSU,PHIHSL,CNHAZS,PHIDSP,
2          CNDSP,ZETEYE,DPHIDS,SF,SM,HF,WRC,TITLE)

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C

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C

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C

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      INTEGER FIRE, WRC, TITLE(20),PRODD,PRODH
      DIMENSION Y(4),WB(20)
      COMMON NSEGQ,NSEGPD,NSEGPB,TAUQ(100),TAUPRD(100),TAUPRH(100),
2          G(100),PRD(100),PRH(100),AKAP(100),C1,C2,C3D,C3H,ZET0,FIRE,

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SUBROUTINE SUBAINT

```

3      PRODD,PRODH,LIMIT,DPHI,TAULIM,LINTER,DELTA,DQDT0,DPRDT0,
4      DPRHT0,Q0,LNORM
      EXTERNAL F
      EXTERNAL QDQ0
      LOGICAL LINTER,LNORM
      CHARACTER CHARTR
C
C COMPUTE INITIAL LAYER TEMPERATURE, INITIAL RATE OF LAYER
C TEMPERATURE RISE, AND INITIAL CONCENTRATIONS.
C
      PHI0=1./((1.-C1/(C1+C2*(ZET0**(5./3.))))
      DPHI0=(C1/C2)*(1./6.)*(2.*DQDT0-5.*(-C1-C2*(ZET0**(5./3.)))/(ZET0
2      *(8./3.))
      CND0=C3D/(C2*(ZET0**(5./3.))
      CNH0=C3H/(C2*(ZET0**(5./3.))
C
C IF IDETH=1, DETECTION BY POC CONCENTRATION IS NOT UNDER
C CONSIDERATION.
C
      IF (IDETH.EQ.1) GO TO 20
      IF (CND0.LT.CNDSP) GO TO 40
      IDETH=1
10     ZETDET=HF
      TAUDET=0.
      CNDETD=CND0
      CNDETH=CNH0
      DPHID=DPHI0
      PHIDET=PHI0
      GO TO 40
C
C IF IDETT=1, DETECTION BY LAYER TEMPERATURE IS NOT UNDER CONSIDERATION
C
20     IF (IDETT.GT.0) GO TO 30
      IF (PHI0.LT.PHIDSP) GO TO 40
      IDETT=1
      GO TO 10
C
C DETECTION IS BY RATE OF TEMPERATURE RISE AND IDETR=0. DOES DETECTION
C OCCUR AT TIME=0.?
C
30     IF (DPHI0.LT.DPHIDS) GO TO 40
      IDETR=1
      GO TO 10
C
C SINCE HF>ZETEYE AT THIS INITIAL TIME, HAZARD CAN ONLY BE BY TEMPER-
C ATURE. DOES HAZARD OCCUR AT TIME=0.?
C
40     IF (PHI0.LT.PHIHSU) GO TO 50
      TAUHAZ=0.
      ZETHAZ=HF
      CNHAZD=CND0
      CNHAZH=CNH0
      PHIHAZ=PHI0
      TAUDET=0.
      ZETDET=HF
      CNDETD=CND0
      CNDETH=CNH0
      DPHID=DPHI0

```

SUBROUTINE SUBAINT

PHIDET=PHI0

GO TO 230

C

C INITIALIZE VARIABLES FOR INTEGRATION.

C

60

Y(1)=ZET0

Y(2)=PHI0

Y(3)=CND0

Y(4)=CNH0

DPHI=DPHI0

TAU2=0.0

IF ((WRC.EQ.1).OR.(WRC.EQ.2)) GO TO 60

IF (WRC.EQ.3) WRITE (6,280) TITLE

IF (WRC.EQ.4) WRITE (6,290) TITLE

IF ((WRC.EQ.3).AND.(LNORM)) WRITE (6,360)

IF ((WRC.EQ.4).AND.(LNORM)) WRITE (6,380)

IF ((WRC.EQ.3).AND.(.NOT.(LNORM))) WRITE (6,370)

IF ((WRC.EQ.4).AND.(.NOT.(LNORM))) WRITE (6,390)

DZF=HF-(Y(1)+DELTA)

DZM=DZF*0.3048

TMF=(Y(2)*530.0)-460.0

TMC=(TMF-32.0)/1.8

AQDQ0=QDQ0(TAU2)

UAQDQ0=AQDQ0*Q0

RRF=DPHI*31800.0

RRC=RRF/1.8

ZF=Y(1)+DELTA

ZM=(Y(1)+DELTA)*0.3048

CND=Y(3)

CNH=Y(4)

ITAU2=IFIX(TAU2)

IF ((WRC.EQ.3).AND.(LNORM)) WRITE (6,400) ITAU2,AQDQ0,DZF,DZM,ZF,
2 ZM,TMF,TMC,RRF,RRC,CND,CNH

IF ((WRC.EQ.4).AND.(LNORM)) WRITE (6,410) ITAU2,TMF,RRF,DZF,ZF,
2 AQDQ0,CND,CNH,TMC,RRC,DZM,ZM

IF ((WRC.EQ.3).AND.(.NOT.(LNORM))) WRITE (6,400) ITAU2,UAQDQ0,DZF,
2 DZM,ZF,ZM,TMF,TMC,RRF,RRC,CND,
3 CNH

IF ((WRC.EQ.4).AND.(.NOT.(LNORM))) WRITE (6,410) ITAU2,TMF,RRF,DZF
2 ,ZF,UAQDQ0,CND,CNH,TMC,RRC,
3 DZM,ZM

C

C INCREMENT TIME STEP AND CONTINUE.

C

60

TAU1=TAU2

TAU2=TAU2+5.

IF (((FIRE.EQ.2).AND.(TAU2.GT.TAUQ(NSEGQ))).OR.

2((PRODD.EQ.2).AND.(TAU2.GT.TAUPRD(NSEGPD))).OR.

3((PRODH.EQ.2).AND.(TAU2.GT.TAUPRH(NSEGPH)))) GO TO 250

IF (TAU2.GT.TAULIM) GO TO 260

Z1=Y(1)+DELTA

Z1I=Y(1)

PHI1=Y(2)

CND1=Y(3)

CNH1=Y(4)

DELTH=0.5

DPHI1=DPHI

C

SUBROUTINE SUBAINT

```

C CALL INTGR TO PERFORM THE INTEGRATION FROM TAU1 TO TAU2.
C
  CALL INTGR (F,TAU1,TAU2,DELTH,4,Y,WB,IER)
C
  IF (IER.LT.32) GO TO 70
C
C THERE IS AN ERROR IN THE INTEGRATION, WRITE ERROR MESSAGE AND
C RETURN TO MAIN.
C
  WRITE (6,330)
  RETURN
70  Z2I=Y(1)
    Z2=Y(1)+DELTA
    PHI2=Y(2)
    CND2=Y(3)
    CNH2=Y(4)
    DPHI2=DPHI
    IF ((WRC.EQ.1).OR.(WRC.EQ.2)) GO TO 80
    DZF=HF-Z2
    DZM=DZF*0.3048
    TMF=(PHI2*530.0)-460.0
    TMC=(TMF-32.0)/1.8
    AQDQ0=GDQ0(TAU2)
    UAQDQ0=AQDQ0*Q0
    RRF=DPHI2*31800.0
    RRC=RRF/1.8
    ZF=Z2
    ZM=ZF*0.3048
    CND=CND2
    CNH=CNH2
    ITAU2=IFIX(TAU2)
    IF ((WRC.EQ.3).AND.(LNORM)) WRITE (6,400) ITAU2,AQDQ0,DZF,DZM,ZF,
2      ZM,TMF,TMC,RRF,RRC,CND,CNH
    IF ((WRC.EQ.4).AND.(LNORM)) WRITE (6,410) ITAU2,TMF,RRF,DZF,ZF,
2      AQDQ0,CND,CNH,TMC,RRC,DZM,ZM
    IF ((WRC.EQ.3).AND.(.NOT.(LNORM))) WRITE (6,400) ITAU2,UAQDQ0,DZF,
2      DZM,ZF,ZM,TMF,TMC,RRF,RRC,CND,
3      CNH
    IF ((WRC.EQ.4).AND.(.NOT.(LNORM))) WRITE (6,410) ITAU2,TMF,RRF,DZF
2      ,ZF,UAQDQ0,CND,CNH,TMC,RRC,DZM
3      ,ZM
C
C IF DETECTION OCCURED BEFORE THE LAST TIME INTERVAL THEN WILL PASS FROM
C HERE TO 120 WITH NO CHANGES. IF DETECTION DID NOT OCCUR BEFORE THE
C LAST TIME INTERVAL THEN CHECK IF DETECTION OCCURED IN LAST TIME INTER-
C VAL. IF SO, THEN FLAG THIS FACT (E.G., SET IDETT=1), COMPUTE PARAME-
C TERS AT THE TIME OF DETECTION AND GO TO 120.
C
80  IF (IDETH.GT.0) GO TO 100
    IF (CND2.LT.CNDSP) GO TO 120
    TAUDET=TAU1+(TAU2-TAU1)*(CNDSP-CND1)/(CND2-CND1)
    IDETH=1
90  ZETDET=Z1+(Z2-Z1)*(TAUDET-TAU1)/(TAU2-TAU1)
    CNDETD=CND1+(CND2-CND1)*(TAUDET-TAU1)/(TAU2-TAU1)
    CNDETH=CNH1+(CNH2-CNH1)*(TAUDET-TAU1)/(TAU2-TAU1)
    PHIDET=PHI1+(PHI2-PHI1)*(TAUDET-TAU1)/(TAU2-TAU1)
    DPHID=DPHI1+(DPHI2-DPHI1)*(TAUDET-TAU1)/(TAU2-TAU1)
    GO TO 120

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SUBROUTINE SUBAINT

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100  IF (IDETT.GT.0) GO TO 110
    IF (PHI2.LT.PHIDSP) GO TO 120
    TAUDET=TAU1+(TAU2-TAU1)*(PHIDSP-PHI1)/(PHI2-PHI1)
    IDETT=1
    GO TO 90
110  IF (IDETR.GT.0) GO TO 120
    IF (DPHI2.LT.DPHIDS) GO TO 120
    TAUDET=TAU1+(TAU2-TAU1)*(DPHIDS-DPHI1)/(DPHI2-DPHI1)
    IDETR=1
    GO TO 90
C
C DID HAZARD OCCUR DURING THE LAST TIME INTERVAL?
C
120  IF (Z2.LT.ZETEYE) GO TO 140
    IF (PHI2.GE.PHIHSU) GO TO 130
    GO TO 60
130  TAUHAZ=TAU1+(TAU2-TAU1)*(PHIHSU-PHI1)/(PHI2-PHI1)
    GO TO 200
140  IF (Z1.GE.ZETEYE) GO TO 150
    GO TO 160
C
C DID HAZARD OCCUR BY HIGH LAYER TEMPERATURE WITHIN THE TIME INTERVAL
C BEFORE Z<ZETEYE? TO ANSWER THIS, COMPUTE TIME WHEN Z=ZETEYE, COMPUTE
C THE TEMPERATURE AT THIS TIME, AND SEE IF THIS TEMPERATURE IS GREATER
C THAN PHITST.
C
150  TAUTST=TAU1+(TAU2-TAU1)*(ZETEYE-Z1)/(Z2-Z1)
    PHITST=PHI1+(PHI2-PHI1)*(TAUTST-TAU1)/(TAU2-TAU1)
    IF (PHITST.GE.PHIHSU) GO TO 130
C
C DID HAZARDOUS CONCENTRATION EXIST PRIOR TO OR AT THE TIME THAT THE
C INTERFACE REACHED ZETEYE? TO ANSWER, COMPUTE THE CONCENTRATION,
C CNHTST, AT TIME TAUTST WHEN THE INTERFACE REACHES ZETEYE, AND COMPARE
C IT TO CNHAZS.
C
    CNHTST=CNH1+(CNH2-CNH1)*(TAUTST-TAU1)/(TAU2-TAU1)
    IF ((CNHTST.LT.CNHAZS).AND.(PHITST.LT.PHIHSL)) GO TO 160
    TAUHAZ=TAUTST
    GO TO 200
160  IF (CNH2.GE.CNHAZS) GO TO 180
    IF (PHI2.LT.PHIHSL) GO TO 60
170  TAUHAZ=TAU1+(TAU2-TAU1)*(PHIHSL-PHI1)/(PHI2-PHI1)
    GO TO 200
180  IF (PHI2.LT.PHIHSL) GO TO 190
C
C COMPUTE TIME WHEN CN=CNHAZS. COMPUTE TIME WHEN PHI=PHIHSL. WHICHEVER
C TIME IS SMALLER IS TAUHAZ.
C
    TAUTSC=TAU1+(TAU2-TAU1)*(CNHAZS-CNH1)/(CNH2-CNH1)
    TAUTSP=TAU1+(TAU2-TAU1)*(PHIHSL-PHI1)/(PHI2-PHI1)
    IF (TAUTSC.LE.TAUTSP) GO TO 190
    GO TO 170
190  TAUHAZ=TAU1+(TAU2-TAU1)*(CNHAZS-CNH1)/(CNH2-CNH1)
200  PHIHAZ=PHI1+(PHI2-PHI1)*(TAUHAZ-TAU1)/(TAU2-TAU1)
    ZETHAZ=Z1+(Z2-Z1)*(TAUHAZ-TAU1)/(TAU2-TAU1)
    CNHAZD=CND1+(CND2-CND1)*(TAUHAZ-TAU1)/(TAU2-TAU1)
    CNHAZH=CNH1+(CNH2-CNH1)*(TAUHAZ-TAU1)/(TAU2-TAU1)
    DPHIH=DPHI1+(DPHI2-DPHI1)*(TAUHAZ-TAU1)/(TAU2-TAU1)

```

SUBROUTINE SUBAINT

```

C
C HAZARD DID OCCUR IN THE LAST TIME INTERVAL. DID DETECTION OCCUR IN THE
C LAST OR ANY PREVIOUS TIME INTERVAL? IF NOT, THEN ASSUME DETECTION
C EVENT TO OCCUR AT THE TIME OF THE ONSET OF HAZARD, AND APPROPRIATELY
C SET THE DETECTION PARAMETERS.
C
      IF (((IDETH.EQ.1).AND.(IDETT.EQ.1)).AND.(IDETR.EQ.1)) GO TO 210
      GO TO 220
210    IF (TAUHAZ.LT.TAUDET) GO TO 220
      GO TO 230
220    TAUDET=TAUHAZ
      PHIDET=PHIHAZ
      ZETDET=ZETHAZ
      CNDETC=CNHAZD
      CNDETH=CNHAZH
      DPHID=DPHI1+(DPHI2-DPHI1)*(TAUDET-TAU1)/(TAU2-TAU1)
C
C CHANGE DIMENSIONLESS RESULTS CORRESPONDING TO THE DETECTION AND
C ONSET OF HAZARD EVENTS TO DIMENSIONAL VALUES AND PRINT THEM OUT.
C
230    TMDETF=PHIDET*530.-460.
      TMDETC=(TMDETF-32.)/1.8
      TMHAZF=PHIHAZ*530.-460.
      TMHAZC=(TMHAZF-32.)/1.8
      RRDETF=DPHID*31800.0
      RRDETC=RRDETF/1.8
      TIMDS=TAUDET
      TIMHS=TAUHAZ
      QDETDQ=QDQ0(TAUDET)
      QHAZDQ=QDQ0(TAUHAZ)
      UQDQDQ=QDETDQ*Q0
      UQHZDQ=QHAZDQ*Q0
      ZDETF=ZETDET
      ZDETM=ZDETF*0.3048
      DZDETF=HF-ZETDET
      DZDETM=DZDETF*0.3048
      ZHAZF=ZETHAZ
      ZHAZM=ZHAZF*0.3048
      DZHAZF=HF-ZETHAZ
      DZHAZM=DZHAZF*0.3048
      RRHAZF=DPHIH*31800.0
      RRHAZC=RRHAZF/1.8
      ITIMDS=IFIX(TIMDS)
      ITIMHS=IFIX(TIMHS)
      ITMEGS=ITIMHS-ITIMDS
C
C WRITE RESULTS FOR THE COMPARTMENT HEIGHT AND AREA UNDER CONSIDERATION.
C
      IF ((WRC.EQ.2).OR.(WRC.EQ.4)) GO TO 240
      IF (WRC.EQ.3) WRITE (6,280) TITLE
      IF ((WRC.EQ.3).AND.(LNORM)) WRITE (6,420)
      IF ((WRC.EQ.3).AND.(.NOT.(LNORM))) WRITE (6,430)
      IF (LNORM) WRITE (6,310) SF,ITIMDS,TMDETF,DZDETF,RRDETF,QDETDQ,
2          CNDETD,ITIMHS,TMHAZF,ZHAZF,QHAZDQ,CNHAZH,ITMEGS,SM,
3          TMDETC,DZDETM,RRDETC,TMHAZC,ZHAZM
      IF (.NOT.(LNORM)) WRITE (6,310) SF,ITIMDS,TMDETF,DZDETF,RRDETF,
2          UQDQDQ,CNDETD,ITIMHS,TMHAZF,ZHAZF,UQHZDQ,CNHAZH
3          ,ITMEGS,SM,TMDETC,DZDETM,RRDETC,TMHAZC,ZHAZM

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SUBROUTINE SUBAINT

```
IF (LINTER) WRITE (6,460)
IF (LINTER) READ (5,300) CHARTR
RETURN
```

```
C
240 WRITE (6,290) TITLE
    IF (LNORM) WRITE (6,440)
    IF (.NOT.(LNORM)) WRITE (6,450)
    WRITE (6,470)
    IF (LNORM) WRITE (6,320) ITIMDS,TMDETF,DZDETF,ZDETF,RRDETF,QDETDQ,
2      CNDETD,CNDETH,TMDETC,DZDETM,ZDETM,RRDETC
    IF (.NOT.(LNORM)) WRITE (6,320) ITIMDS,TMDETF,DZDETF,ZDETF,RRDETF,
2      UQD TDQ,CNDETD,CNDETH,TMDETC,DZDETM,ZDETM,RRDETC
    WRITE (6,480)
    IF (LNORM) WRITE (6,320) ITIMHS,TMHAZF,DZHAZF,ZHAZF,RRHAZF,QHAZDQ,
2      CNHAZD,CNHAZH,TMHAZC,DZHAZM,ZHAZM,RRHAZC
    IF (.NOT.(LNORM)) WRITE (6,320) ITIMHS,TMHAZF,DZHAZF,ZHAZF,RRHAZF,
2      UQHZDQ,CNHAZD,CNHAZH,TMHAZC,DZHAZM,ZHAZM,RRHAZC
    WRITE (6,490) ITMEGS
    IF (LINTER) WRITE (6,460)
    IF (LINTER) READ (5,300) CHARTR
    RETURN
```

```
C
250 WRITE (6,350)
    GO TO 270
260 WRITE (6,340)
270 LIMIT=1
    IF (LINTER) WRITE (6,460)
    IF (LINTER) READ (5,300) CHARTR
    RETURN
```

```
C
C
280 FORMAT (1H1,20X,20A4/)
290 FORMAT(1H1,20A4/)
300 FORMAT(A1)
310 FORMAT(1H0,1X,F8.0,3X,I5,3(3X,F7.2),3X,F8.2,3X,E9.4,3X,I5,2(3X,F7.
22),3X,F8.2,3X,E9.4,3X,I5/1X,'('',F8.2,'')',9X,'('',F7.2,'')',1X,'('',F7
3.2,'') ('',F7.2,'')',32X,'('',F7.2,'') ('',F7.2,'')'/)
320 FORMAT(1H0,I5,4(2X,F7.2),2X,F8.2,2(2X,E10.5)/7X,'('',F7.2,'')('',F7.2
2,'')('',F7.2,'')('',F7.2,'')'/)
330 FORMAT (34H PROBLEM IN INTEGRATION IER GT 32/)
340 FORMAT (1H0,3X, '---THE TIME TAULIM HAS BEEN EXC
2EDED.'/) CONTINUE WITH THE NEXT COMPARTMENT HEIGHT OR SPECIFIED '
3/5X,'DETECTION CRITERIA.--')
350 FORMAT (1H0,3X,'---THE UPPER LIMIT OF THE DIGITAL DATA HAS BEEN EXC
2EDED.'/) CONTINUE WITH THE NEXT COMPARTMENT HEIGHT OR SPECIFIED '
3/5X,'DETECTION CRITERIA.--')
360 FORMAT(1' 0,1X,'TIME',8X,'Q/Q0',7X,'LAYER THICKNESS INTERFACE EL
2EVATION LAYER TEMPERATURE',7X,'RATE OF RISE',10X,'CONCENTRATION'
3/' (SECS)',19X,'(FT)',6X,'(M)',8X,'(FT)',6X,'(M)',7X,'(F)',6X,'(C)
4',9X,'(F/MIN) (C/MIN) DETECTABLE HAZARDOUS'/1H ,111X,'POC',8X
5,'POC')
370 FORMAT(1H0,1X,'TIME',8X,' Q ',7X,'LAYER THICKNESS INTERFACE EL
2EVATION LAYER TEMPERATURE',7X,'RATE OF RISE',10X,'CONCENTRATION'
3/' (SEC)',8X,'KW',5X,'(FT)',6X,'(M)',8X,'(FT)',6X,'(M)',8X,'(F)',6
4X,'(C)',9X,'(F/MIN) (C/MIN) DETECTABLE HAZARDOUS'/1H ,111X,'P
5OC',8X,'POC')
380 FORMAT(1H0,17X,'RATE OF LAYER LAYER',13X,'DETECTABLE HAZARDOU
2S'/2X,'TIME TEMP. RISE THICKNESS ELEVAT. Q/Q0',7X,'POC'
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SUBROUTINE SUBAINT

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3,8X,'POC'/56X,'CONCEN.      CONCEN.'/2X,'SEC      DEG F      DEGF/M
4FT',7X,'FT'/9X,'(DEG C) (DEGC/M)      (M)      (M)')
300  FORMAT(1H0,17X,'RATE OF      LAYER      LAYER',13X,'DETECTABLE HAZARDOU
2S'/2X,'TIME      TEMP.      RISE      THICKNESS ELEVAT.      Q      ',7X,'POC'
3,8X,'POC'/56X,'CONCEN.      CONCEN.'/2X,'SEC      DEG F      DEGF/M
4FT',7X,'FT',8X,'KW'/9X,'(DEG C) (DEGC/M)      (M)      (M)')
400  FORMAT(1H0,I5,5X,F8.2,4(5X,F7.2,2X,F7.2),5X,E9.4,2X,E9.4/)
410  FORMAT(1H0,1X,I5,4(2X,F7.2),2X,F8.2,2(2X,E9.4)/8X,4('(',F7.2,')')/
2)
420  FORMAT(1H0,31X,'LAYER      RATE OF',14X,'DETECTABLE',19X,'INTERFACE'
2,13X,'HAZARDOUS'/4X,'AREA      TIME      TEMP.      THICKNESS      RISE',
36X,'Q/QO      CONCEN.      TIME      TEMP.      ELEVATION      Q/QO',5X,'
4CONCEN.      AVAILABLE'/14X,'AT',7X,'AT',8X,'AT',9X,'AT',8X,'AT',9X,'A
5T',8X,'AT',7X,'AT',8X,'AT',9X,'AT',9X,'AT',6X,'EGRESS'/10X,'DETECT
6ION DETECTION DETECTION DETECTION DETECTION DETECTION DETECTION HAZARD
7HAZARD      HAZARD      HAZARD      HAZARD      TIME'//3X,'FT**2',6X,'S
8EC      DEG F',6X,'FT',6X,'DEGF/M',28X,'SEC      DEG F',6X,'FT',30X,
9'SEC'/3X,'(M**2)',12X,'(DEG C)      (M)      (DEGC/M)',33X,'(DEG C)
*      (M)'//)
430  FORMAT(1H0,31X,'LAYER      RATE OF',14X,'DETECTABLE',19X,'INTERFACE'
2,13X,'HAZARDOUS'/4X,'AREA      TIME      TEMP.      THICKNESS      RISE',
36X,'Q      CONCEN.      TIME      TEMP.      ELEVATION      Q      ',5X,'
4CONCEN.      AVAILABLE'/14X,'AT',7X,'AT',8X,'AT',9X,'AT',8X,'AT',9X,'A
5T',8X,'AT',7X,'AT',8X,'AT',9X,'AT',9X,'AT',6X,'EGRESS'/10X,'DETECT
6ION DETECTION DETECTION DETECTION DETECTION DETECTION DETECTION HAZARD
7HAZARD      HAZARD      HAZARD      HAZARD      TIME'//3X,'FT**2',6X,'S
8EC      DEG F',6X,'FT',6X,'DEGF/M',7X,'KW',19X,'SEC      DEG F',6X,'
9FT',10X,'KW',18X,'SEC'/3X,'(M**2)',12X,'(DEG C)      (M)      (DEGC/
*M)',33X,'(DEG C)      (M)'//)
440  FORMAT(1H0,8X,'LAYER      LAYER      INTER.      RATE OF',12X,'DETECTABLE
2 HAZARDOUS'/2X,'TIME      TEMP.      THICKNESS ELEVAT.      RISE',6X,'Q/QO',
37X,'POC',9X,'POC'/3X,'SEC      DEG F      FT',7X,'FT      DEGF/M',14X,'
4CONCEN.      CONCEN.'/8X,'(DEG C)      (M)',6X,'(M)      (DEGC/M)')
450  FORMAT(1H0,8X,'LAYER      LAYER      INTER.      RATE OF',12X,'DETECTABLE
2 HAZARDOUS'/2X,'TIME      TEMP.      THICKNESS ELEVAT.      RISE',6X,'Q      ',
37X,'POC',9X,'POC'/3X,'SEC      DEG F      FT',7X,'FT      DEGF/M',6X,'K
4W',6X,'CONCEN.      CONCEN.'/8X,'(DEG C)      (M)',6X,'(M)      (DEGC/M)
5')
460  FORMAT('OPRESS CARRIAGE RETURN TO CONTINUE.')
470  FORMAT(' ****DETECTION CHARACTERISTICS****')
480  FORMAT(' ****HAZARD CHARACTERISTICS****')
490  FORMAT(' ****SAFE AVAILABLE EGRESS TIME = ',I5,' SECONDS****')
C
END

```


SUBROUTINE INTGR

C THIS IS EGRESS*ASET.INTGR. IT REQUIRES EGRESS*ASET.SUBF.

C

C*****

C THIS SUBROUTINE WILL INTEGRATE THE EQUATIONS FOR COMPUTING THE
C INTERFACE POSITION AS IT DROPS FROM THE CEILING, THE HISTORY OF THE
C AVERAGE UPPER LAYER TEMPERATURE, AND THE HISTORY OF THE PRODUCTS OF
C COMBUSTION CONCENTRATIONS IN THE UPPER LAYER.

C*****

C

SUBROUTINE INTGR (F,A,B,H,N,X0,WK,IER)

C

C*****

C

DIMENSION WK(1),X0(1)

INTEGER ZXR

LOGICAL LD,LH,LI,LJ

DATA E5/.5E-4/

IER=0

IF (A-B) 30,10,30

10 DO 20 I=1,N

X0(I)=0.0

20 CONTINUE

RETURN

30 IN1=N+N

IN2=IN1+N

HMIN=0.01*ABS(H)

LH=.TRUE.

LI=.TRUE.

LJ=.TRUE.

H=SIGN(ABS(H),B-A)

X=A

40 XS=X

DO 50 J=1,N

IWK0=N+J

WK(IWK0)=X0(J)

50 CONTINUE

60 HS=H

D=X+H-B

LD=.TRUE.

IF (.NOT.((H.GT.0.0.AND.D.GE.0.0).OR.(H.LT.0.0.AND.D.LE.0.0))) GO
2 TO 70

H=B-X

LI=.FALSE.

70 H3=H/3.

DO 210 ZXR=1,5

CALL F (X0,X,WK)

DO 170 I=1,N

D=H3*WK(I)

IWK0=N+I

IWK1=IN1+I

IWK2=IN2+I

GO TO (80,90,100,110,120), ZXR

80 T=D

WK(IWK1)=D

GO TO 130

90 T=0.5*(D+WK(IWK1))

SUBROUTINE INTGR

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      GO TO 130
100    T=3.*D
      WK(IWK2)=T
      T=.375*(T+WK(IWK1))
      GO TO 130
110    T=WK(IWK1)+4.*D
      WK(IWK1)=T
      T=1.5*(T-WK(IWK2))
      GO TO 130
120    T=0.5*(D+WK(IWK1))
      D=ABS(T+T-1.5*(D+WK(IWK2)))
130    X0(I)=WK(IWK0)+T
      IF (ZXR.NE.5) GO TO 170
      R=ABS(X0(I))
      T=E5
      IF (R.GE.1.E-3) T=R*E5
      IF (D.LT.T.OR.(.NOT.LH)) GO TO 160
      LI=.TRUE.
      LJ=.FALSE.
      H=H/2.
      IF (ABS(H).GE.HMIN) GO TO 140
      H=SIGN(1.,H)*HMIN
      LH=.FALSE.
140    DO 150 J=1,N
          IWK0=N+J
          X0(J)=WK(IWK0)
150    CONTINUE
      X=XS
      GO TO 60
160    IF (D.GE.0.03125*T) LD=.FALSE.
170    CONTINUE
      GO TO (180,210,190,200,210), ZXR
180    X=X+H3
      GO TO 210
190    X=X+0.5*H3
      GO TO 210
200    X=X+0.5*H
210    CONTINUE
      IF (.NOT.(LD.AND.LI.AND.LJ)) GO TO 220
      H=2.*H
      LH=.TRUE.
220    LJ=.TRUE.
      IF (LI) GO TO 40
      H=HS
      IF (LH.OR.LD) RETURN
      IER=33
      WRITE (6,230)
      RETURN
C
C
230    FORMAT(' WARNING CONVERGENCE WAS NOT OBTAINED IN INTGR SUBROUTINE'
2)
C
      END

```

SUBROUTINE SUBF

```

C THIS IS EGRESS*ASET.SUBF. IT IS REQUIRED BY INTGR.
C
C*****
C THIS IS USED IN INTGR INTEGRATING ROUTINE.
C THUS  DX/DT=F(X(T),T)
C*****
C
      SUBROUTINE F (X0,T,XP)
C
C *****
C
      COMMON NSEGQ,NSEGPD,NSEGPB,TAUQ(100),TAUPRD(100),TAUPRH(100),
2          Q(100),PRD(100),PRH(100),AKAP(100),C1,C2,C3D,C3H,ZET0,FIRE,
3          PRODD,PRODH,LIMIT,DPHI,TAULIM,LINTER,DELTA,DQDT0,DPRDT0,
4          DPRHT0,Q0,LNORM
      DIMENSION X0(4),XP(4)
      EXTERNAL QDQ0
      EXTERNAL PRDPRO
      EXTERNAL PRHPRO
      LOGICAL LINTER,LNORM
      IF (T.GT.0.0) GO TO 10
      XP(1)=-C1-C2*(ZET0**(5./3.))
      XP(2)=(C1/C2)*(1./6.)*(2.*DQDT0-5.*XP(1))/(ZET0**(8./3.))
      XP(3)=((5.*C1*C3D)/(6.*C2*(ZET0**(8./3.)))*(1.+(3.*ZET0*DPRDT0)/(5
2.*C1)-ZET0*DQDT0/(5.*C1)+C2*(ZET0**(5./3.))/C1)
      XP(4)=((5.*C1*C3H)/(6.*C2*(ZET0**(8./3.)))*(1.+(3.*ZET0*DPRHT0)/(5
2.*C1)-ZET0*DQDT0/(5.*C1)+C2*(ZET0**(5./3.))/C1)
      GO TO 40
10     IF (X0(1).LE.0.0) GO TO 20
      XP(1)=-C1*QDQ0(T)
      XP(1)=XP(1)-C2*(QDQ0(T)**(1./3.))*(X0(1)**(5./3.))
      XP(2)=(X0(2)**2.)*(C1*QDQ0(T)+(1.-(1./X0(2)))*XP(1))/(ZET0-X0(1))
      XP(3)=X0(2)*(C3D*PRDPRO(T)-X0(3)*C2*(QDQ0(T)**(1./3.))*(X0(1)**(5
2/3.)))/(ZET0-X0(1))
      XP(4)=X0(2)*(C3H*PRHPRO(T)-X0(4)*C2*(QDQ0(T)**(1./3.))*(X0(1)**(5
2/3.)))/(ZET0-X0(1))
      GO TO 40
20     IF (X0(1).LE.-DELTA) GO TO 30
      XP(1)=-C1*QDQ0(T)
      XP(2)=(X0(2)*C1*QDQ0(T))/(ZET0-X0(1))
      XP(3)=(X0(2)*C3D*PRDPRO(T))/(ZET0-X0(1))
      XP(4)=(X0(2)*C3H*PRHPRO(T))/(ZET0-X0(1))
      GO TO 40
30     XP(1)=0.0
      XP(2)=(X0(2)*C1*QDQ0(T))/(ZET0+DELTA)
      XP(3)=(X0(2)*C3D*PRDPRO(T))/(ZET0+DELTA)
      XP(4)=(X0(2)*C3H*PRHPRO(T))/(ZET0+DELTA)
40     DPHI=XP(2)
      RETURN
      END

```

SUBROUTINE INPUT

```

C THIS IS EGRESS*ASET.INPUT
C
C*****
C THIS IS AN ERROR CHECKING ROUTINE. IT CHECKS THE INPUT DATA TO
C INSURE THAT IT IS CORRECT.
C*****
C
  SUBROUTINE INPUT (VARIBL,IEND)
C
C *****
C
  COMMON NSEGQ,NSEGPD,NSEGPH,TAUQ(100),TAUPRD(100),TAUPRH(100),
2      Q(100),PRD(100),PRH(100),AKAP(100),C1,C2,C3D,C3H,ZETO,FIRE,
3      PRODD,PRODH,LIMIT,DPHI,TAULIM,LINTER,DELTA,DQDQTO,DPRDQTO,
4      DPRHTO,QO,LNORM
  LOGICAL LINTER,LNORM
  CHARACTER L,ICHECK
  DATA L/'Y'/
10  WRITE (6,50)
  READ (5,60) ICHECK
  IF (ICHECK.EQ.L) RETURN
  WRITE (6,70)
20  READ (5,*,ERR=40,END=30) VARIBL
  WRITE (6,*) VARIBL
  GO TO 10
30  IEND=999
  RETURN
40  WRITE (6,80)
  GO TO 20
C
C
50  FORMAT(' IS THIS CORRECT (Y/N) ?')
60  FORMAT(A1)
70  FORMAT(' ENTER THE CORRECT VALUE(S).')
80  FORMAT(' ====> INCORRECT INPUT - TRY AGAIN <====')
C
  END

```


SUBROUTINE INPUT2

C THIS IS EGRESS*ASET.INPUT2

C

C*****

C THIS IS AN ERROR CHECKING ROUTINE. IT CHECKS THE DATA POINT

C INPUT TO INSURE THAT IT IS CORRECT.

C*****

C

SUBROUTINE INPUT2 (TAUVAR,RATVAR,ITYPE)

C

C*****

C

COMMON NSEGG,NSEGGPD,NSEGGPH,TAUQ(100),TAUPRD(100),TAUPRH(100),
2 Q(100),PRD(100),PRH(100),AKAP(100),C1,C2,C3D,C3H,ZETO,FIRE,
3 PRODD,PRODH,LIMIT,DPHI,TAULIM,LINTER,DELTA,DQD0,DPRD0,
4 DPRH0,Q0,LNORM

LOGICAL LINTER,LNORM

DIMENSION TAUVAR(100),RATVAR(100)

CHARACTER L,ICHECK

DATA L/'Y'/

10 IF (ITYPE.EQ.1) WRITE (6,40)

IF (ITYPE.NE.1) WRITE (6,50)

READ (5,60) ICHECK

IF (ICHECK.EQ.L) RETURN

IF (ITYPE.EQ.1) WRITE (6,70)

IF (ITYPE.NE.1) WRITE (6,80)

20 IF (ITYPE.EQ.1) READ (5,*,ERR=30) N,RATVAR(N),TAUVAR(N)

IF (ITYPE.NE.1) READ (5,*,ERR=30) N,TAUVAR(N),RATVAR(N)

IF (ITYPE.EQ.1) WRITE (6,90) (N,RATVAR(N),TAUVAR(N),N=1,NSEGG)

IF (ITYPE.EQ.2) WRITE (6,120) (N,TAUVAR(N),N,RATVAR(N),N=1,NSEGG)

IF (ITYPE.EQ.3) WRITE (6,100) (N,TAUVAR(N),N,RATVAR(N),N=1,NSEGGPD)

IF (ITYPE.EQ.4) WRITE (6,110) (N,TAUVAR(N),N,RATVAR(N),N=1,NSEGGPH)

GO TO 10

30 WRITE (6,130)

GO TO 20

C

C

40 FORMAT(' ARE THE EQUATIONS CORRECT (Y/N) ?')

50 FORMAT(' ARE THE DATA POINTS CORRECT (Y/N) ?')

60 FORMAT(A1)

70 FORMAT(' ENTER THE NUMBER OF AN INCORRECT EQUATION, THE CORRECT RA
2TE,'/' AND THE CORRECT EXPONENTIAL FACTOR.')

80 FORMAT(' ENTER THE NUMBER OF AN INCORRECT DATA POINT, THE CORRECT
2TIME,'/' AND THE CORRECT RATE.')

90 FORMAT(5X,I3,') Q = ',F8.2,' EXP(',F7.4,'(T-T1))'/'

100 FORMAT(1P,'TAUPRD(',I3,') = ',F6.0,5X,'PRD(',I3,') = ',E12.4)

110 FORMAT(1H,'TAUPRH(',I3,') = ',F6.0,5X,'PRH(',I3,') = ',E12.4)

120 FORMAT(1H,'TAUQ(',I3,') = ',F6.0,5X,'Q(',I3,') = ',E12.4)

130 FORMAT(' ===> INCORRECT INPUT - TRY AGAIN <===')

C

END

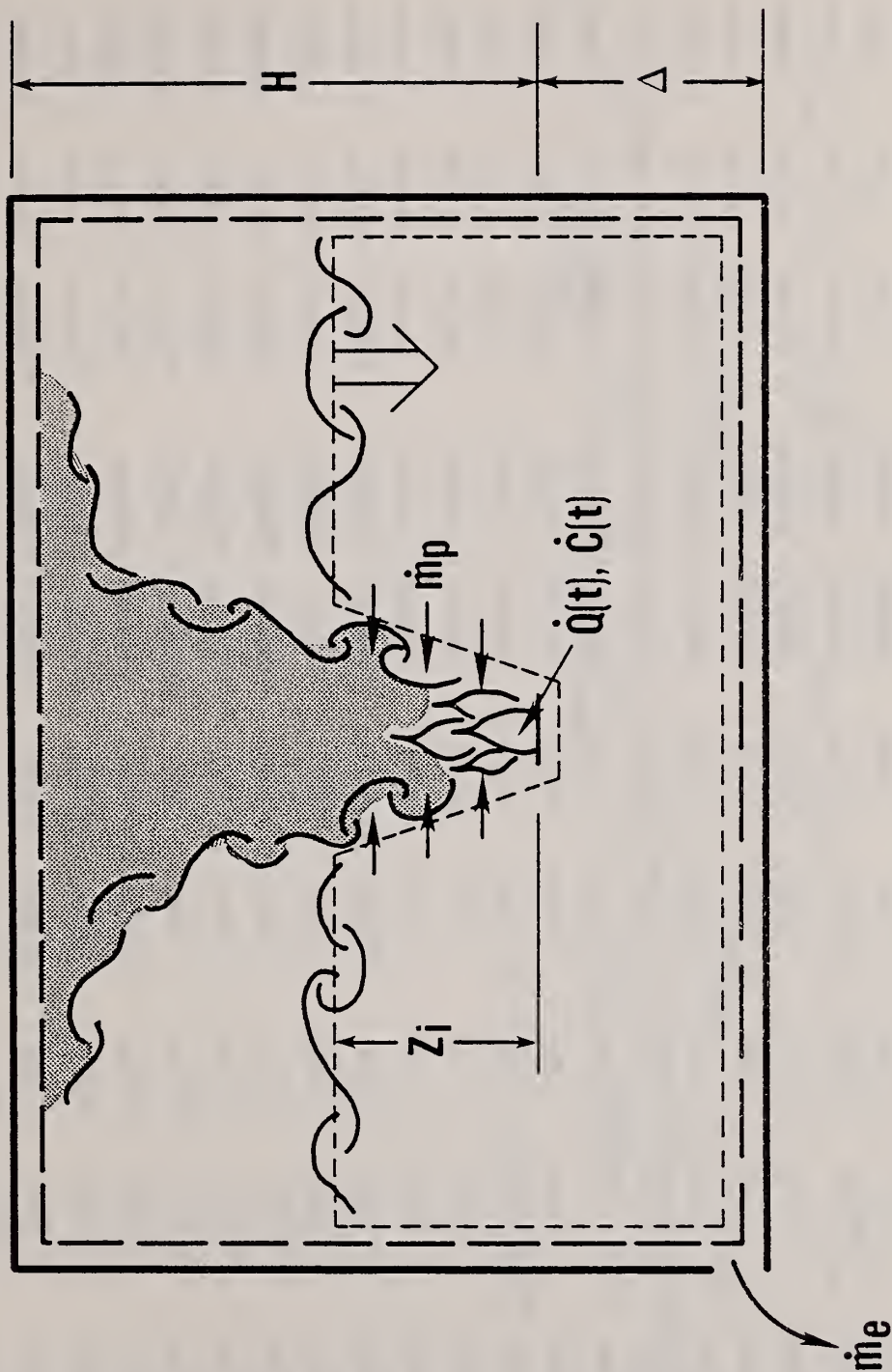


Figure 1. Simple illustration of fire-in-enclosure flow dynamics

CONSTANT FIRE, Q = 1320 KW

TIME (SEC)	Q KW	LAYER THICKNESS (FT)	INTERFACE ELEVATION (FT)	LAYER TEMPERATURE (F)	RATE OF RISE (F/MIN)	CONCENTRATION DETECTABLE HAZARDOUS POC
0	1320.00	.00	10.00	288.31	21.14	.0000
5	1320.00	.10	9.90	290.07	21.23	.0000
10	1320.00	.19	9.81	291.84	21.32	.0000
15	1320.00	.29	9.71	293.62	21.41	.0000
20	1320.00	.38	9.62	295.41	21.50	.0000
25	1320.00	.47	9.53	297.21	21.59	.0000
30	1320.00	.56	9.44	299.01	21.68	.0000
35	1320.00	.65	9.35	300.82	21.77	.0000
40	1320.00	.74	9.26	302.64	21.86	.0000
45	1320.00	.83	9.17	304.46	21.95	.0000
50	1320.00	.92	9.08	306.30	22.05	.0000
55	1320.00	1.00	9.00	308.14	22.14	.0000
60	1320.00	1.09	8.91	309.99	22.23	.0000
65	1320.00	1.17	8.83	311.84	22.33	.0000
70	1320.00	1.26	8.74	313.71	22.42	.0000
75	1320.00	1.34	8.66	315.56	22.51	.0000
80	1320.00	1.42	8.58	317.46	22.61	.0000
85	1320.00	1.50	8.50	319.35	22.70	.0000
90	1320.00	1.58	8.42	321.24	22.80	.0000
95	1320.00	1.66	8.34	323.15	22.89	.0000
100	1320.00	1.74	8.26	325.06	22.99	.0000
105	1320.00	1.82	8.18	326.98	23.09	.0000
110	1320.00	1.89	8.11	328.91	23.18	.0000
115	1320.00	1.97	8.03	330.84	23.28	.0000
120	1320.00	2.05	7.95	332.79	23.38	.0000
125	1320.00	2.12	7.88	334.74	23.48	.0000

Figure 2. Computer output from batch run of Example 1

130	1320.00	2.19	.67	7.81	2.38	336.70	169.28	23.57	13.10	.0000	.2630-001
135	1320.00	2.27	.69	7.73	2.36	338.67	170.37	23.67	13.15	.0000	.2649-001
140	1320.00	2.34	.71	7.66	2.33	340.65	171.47	23.77	13.21	.0000	.2669-001
145	1320.00	2.41	.74	7.59	2.31	342.63	172.57	23.87	13.26	.0000	.2688-001
150	1320.00	2.48	.76	7.52	2.29	344.62	173.68	23.97	13.32	.0000	.2708-001
155	1320.00	2.55	.78	7.45	2.27	346.63	174.79	24.07	13.37	.0000	.2728-001
160	1320.00	2.62	.80	7.38	2.25	348.64	175.91	24.17	13.43	.0000	.2747-001
165	1320.00	2.69	.82	7.31	2.23	350.65	177.03	24.27	13.48	.0000	.2767-001
170	1320.00	2.76	.84	7.24	2.21	352.68	178.16	24.37	13.54	.0000	.2787-001
175	1320.00	2.83	.86	7.17	2.19	354.72	179.29	24.48	13.60	.0000	.2807-001
180	1320.00	2.90	.88	7.10	2.17	356.76	180.42	24.58	13.65	.0000	.2828-001
185	1320.00	2.96	.90	7.04	2.14	358.81	181.56	24.68	13.71	.0000	.2848-001
190	1320.00	3.03	.92	6.97	2.12	360.87	182.71	24.78	13.77	.0000	.2968-001
195	1320.00	3.09	.94	6.91	2.10	362.94	183.86	24.89	13.83	.0000	.2888-001

CONSTANT FIRE, Q = 1320 KW

AREA	TIME AT DETECTION	TEMP. AT DETECTION	LAYER THICKNESS AT DETECTION	RATE OF RISE AT DETECTION	Q AT DETECTION	DETECTABLE CONCEN. AT DETECTION	TIME AT HAZARD	TEMP. AT HAZARD	INTERFACE ELEVATION AT HAZARD	Q AT HAZARD	HAZARDOUS CONCEN. AT HAZARD	AVAILABLE EGRESS TIME
FT**2 (M**2)	SEC	DEG F (DEG C)	FT (M)	DEGF/M (DEGC/M)	KW		SEC	DEG F (DEG C)	FT (M)	KW		SEC
10000. (929.00)	0	288.31 (142.39)	.00 (.00)	21.14 (11.74)	1320.00	.0000	191	361.40 (183.00)	6.95 (2.12)	1320.00	.2873-001	191

Figure 2. continued

MULTI-EXPONENTIAL FIRE GROWTH

TIME (SECS)	Q/Q0	LAYER THICKNESS (FT)	LAYER THICKNESS (M)	INTERFACE ELEVATION (FT)	INTERFACE ELEVATION (M)	LAYER TEMPERATURE (F)	LAYER TEMPERATURE (C)	RATE OF RISE (F/MIN)	RATE OF RISE (C/MIN)	DETECTABLE POC	CONCENTRATION HAZARDOUS POC
0	1.00	.00	.00	20.00	6.10	71.98	22.21	.13	.07	.0000	.2871-004
5	1.13	.07	.02	19.93	6.07	72.07	22.26	1.15	.64	.0000	.3005-004
10	1.28	.15	.05	19.85	6.05	72.17	22.32	1.24	.69	.0000	.3150-004
15	1.45	.23	.07	19.77	6.03	72.27	22.37	1.33	.74	.0000	.3305-004
20	1.65	.31	.09	19.69	6.00	72.39	22.44	1.44	.80	.0000	.3473-004
25	1.87	.39	.12	19.61	5.98	72.51	22.51	1.55	.86	.0000	.3654-004
30	2.12	.48	.15	19.52	5.95	72.65	22.58	1.68	.93	.0000	.3850-004
35	2.40	.57	.17	19.43	5.92	72.79	22.66	1.81	1.01	.0000	.4061-004
40	2.72	.66	.20	19.34	5.89	72.95	22.75	1.96	1.09	.0000	.4289-004
45	3.08	.76	.23	19.24	5.86	73.12	22.85	2.12	1.18	.0000	.4536-004
50	3.49	.86	.26	19.14	5.83	73.31	22.95	2.29	1.27	.0000	.4803-004
55	3.96	.96	.29	19.04	5.80	73.50	23.06	2.48	1.38	.0000	.5092-004
60	4.48	1.07	.33	18.93	5.77	73.72	23.18	2.69	1.50	.0000	.5405-004
65	5.08	1.18	.36	18.82	5.74	73.95	23.31	2.92	1.62	.0000	.5744-004
70	5.75	1.29	.39	18.71	5.70	74.21	23.45	3.17	1.76	.0000	.6112-004
75	6.52	1.41	.43	18.59	5.67	74.48	23.60	3.44	1.91	.0000	.6512-004
80	7.39	1.53	.47	18.47	5.63	74.78	23.77	3.73	2.07	.0000	.6945-004
85	8.37	1.65	.50	18.35	5.59	75.10	23.95	4.06	2.25	.0000	.7417-004
90	9.49	1.78	.54	18.22	5.55	75.46	24.14	4.41	2.45	.0000	.7929-004
95	10.75	1.91	.58	18.09	5.51	75.84	24.36	4.80	2.67	.0000	.8486-004
100	12.18	2.05	.63	17.95	5.47	76.26	24.59	5.23	2.90	.0000	.9093-004
105	13.90	2.19	.67	17.81	5.43	76.71	24.84	5.69	3.16	.0000	.9754-004
110	15.64	2.34	.71	17.66	5.38	77.21	25.12	6.21	3.45	.0000	.1047-003
115	17.73	2.48	.76	17.52	5.34	77.75	25.42	6.77	3.76	.0000	.1126-003
120	20.09	2.64	.80	17.36	5.29	78.34	25.74	7.39	4.11	.0000	.1212-003
125	22.76	2.79	.85	17.21	5.24	78.98	26.10	8.07	4.48	.0000	.1305-003

Figure 3. Computer output from batch run of Example 2

130	25.79	2.96	.90	17.04	5.19	79.68	26.49	8.82	4.90	.0000	.1407-003
135	29.22	3.12	.95	16.88	5.14	80.45	26.92	9.65	5.36	.0000	.1519-003
140	33.12	3.29	1.00	16.71	5.09	81.29	27.39	10.56	5.86	.0000	.1641-003
145	37.52	3.47	1.06	16.53	5.04	82.22	27.90	11.56	6.42	.0000	.1775-003
150	40.99	3.65	1.11	16.35	4.98	83.21	28.45	12.03	6.69	.0000	.1920-003
155	43.09	3.83	1.17	16.17	4.93	84.21	29.01	11.94	6.63	.0000	.2065-003
160	45.30	4.01	1.22	15.99	4.87	85.20	29.56	11.91	6.61	.0000	.2209-003
165	47.62	4.19	1.28	15.81	4.82	86.20	30.11	11.93	6.63	.0000	.2353-003
170	50.07	4.37	1.33	15.63	4.76	87.19	30.66	12.01	6.67	.0000	.2498-003
175	52.63	4.55	1.39	15.45	4.71	88.20	31.22	12.14	6.75	.0000	.2645-003
180	55.33	4.73	1.44	15.27	4.65	89.22	31.79	12.31	6.84	.0000	.2793-003
185	58.17	4.91	1.50	15.09	4.60	90.25	32.36	12.53	6.96	.0000	.2943-003
190	61.15	5.09	1.55	14.91	4.55	91.31	32.95	12.78	7.10	.0000	.3096-003
195	64.29	5.27	1.61	14.73	4.49	92.38	33.55	13.06	7.26	.0000	.3252-003
200	67.58	5.44	1.66	14.56	4.44	93.49	34.16	13.39	7.44	.0000	.3413-003
205	71.05	5.62	1.71	14.38	4.38	94.62	34.79	13.74	7.64	.0000	.3577-003
210	74.69	5.80	1.77	14.20	4.33	95.78	35.43	14.14	7.85	.0000	.3746-003
215	78.52	5.98	1.82	14.02	4.27	96.97	36.10	14.56	8.09	.0000	.3919-003
220	82.54	6.16	1.88	13.84	4.22	98.20	36.78	15.02	8.34	.0000	.4098-003
225	86.78	6.33	1.93	13.67	4.17	99.48	37.49	15.51	8.62	.0000	.4283-003
230	91.22	6.51	1.98	13.49	4.11	100.79	38.22	16.04	8.91	.0000	.4474-003
235	95.90	6.69	2.04	13.31	4.06	102.15	38.97	16.61	9.23	.0000	.4672-003
240	100.82	6.87	2.09	13.13	4.00	103.56	39.76	17.21	9.56	.0000	.4877-003
245	105.99	7.04	2.15	12.96	3.95	105.02	40.57	17.85	9.92	.0000	.5089-003
250	111.42	7.22	2.20	12.78	3.90	106.54	41.41	18.53	10.29	.0000	.5309-003
255	117.14	7.40	2.25	12.60	3.84	108.11	42.28	19.25	10.69	.0000	.5538-003
260	123.14	7.57	2.31	12.43	3.79	109.75	43.19	20.01	11.12	.0000	.5775-003
265	129.45	7.75	2.36	12.25	3.73	111.45	44.14	20.82	11.56	.0000	.6023-003
270	136.09	7.93	2.42	12.07	3.68	113.22	45.12	21.67	12.04	.0000	.6280-003

Figure 3. continued

275	143.07	8.10	2.47	11.90	3.63	115.06	46.14	22.57	12.54	.0000	.6548-003
280	150.40	8.28	2.52	11.72	3.57	116.98	47.21	23.52	13.06	.0000	.6826-003
285	158.12	8.46	2.58	11.54	3.52	118.98	48.32	24.52	13.62	.0000	.7117-003
290	166.22	8.63	2.63	11.37	3.46	121.07	49.48	25.58	14.21	.0000	.7420-003
295	174.74	8.81	2.69	11.19	3.41	123.24	50.69	26.69	14.83	.0000	.7737-003
300	183.70	8.99	2.74	11.01	3.36	125.52	51.95	27.87	15.48	.0000	.8067-003
305	193.12	9.17	2.79	10.83	3.30	127.89	53.27	29.11	16.17	.0000	.8412-003
310	203.02	9.35	2.85	10.65	3.25	130.37	54.65	30.42	16.90	.0000	.8773-003
315	213.43	9.52	2.90	10.48	3.19	132.96	56.09	31.81	17.67	.0000	.9149-003
320	224.38	9.70	2.96	10.30	3.14	135.68	57.60	33.27	18.48	.0000	.9543-003
325	235.88	9.88	3.01	10.12	3.08	138.51	59.17	34.81	19.34	.0000	.9955-003
330	247.97	10.07	3.07	9.93	3.03	141.48	60.82	36.44	20.24	.0000	.1039-002
335	260.69	10.25	3.12	9.75	2.97	144.59	62.55	38.15	21.20	.0000	.1084-002
340	274.05	10.43	3.18	9.57	2.92	147.84	64.36	39.97	22.20	.0000	.1131-002
345	288.11	10.61	3.24	9.39	2.86	151.25	66.25	41.88	23.27	.0000	.1181-002
350	301.44	10.80	3.29	9.20	2.80	154.82	68.23	43.66	24.26	.0000	.1233-002
355	309.07	10.98	3.35	9.02	2.75	158.49	70.27	44.48	24.71	.0000	.1286-002
360	316.89	11.17	3.40	8.83	2.69	162.24	72.35	45.35	25.20	.0000	.1340-002
365	324.91	11.35	3.46	8.65	2.64	166.06	74.48	46.28	25.71	.0000	.1396-002
370	333.14	11.53	3.51	8.47	2.58	169.95	76.64	47.25	26.25	.0000	.1452-002
375	341.57	11.71	3.57	8.29	2.53	173.93	78.85	48.28	26.82	.0000	.1510-002
380	350.22	11.88	3.62	9.12	2.47	179.00	81.11	49.37	27.43	.0000	.1569-002
385	359.08	12.06	3.68	7.94	2.42	182.16	83.42	50.51	28.06	.0000	.1630-002
390	368.17	12.24	3.73	7.76	2.37	186.42	85.79	51.70	28.72	.0000	.1692-002
395	377.49	12.41	3.78	7.59	2.31	190.78	88.21	52.95	29.42	.0000	.1755-002
400	387.05	12.59	3.84	7.41	2.26	195.25	90.69	54.26	30.14	.0000	.1820-002
405	396.85	12.76	3.89	7.24	2.21	199.82	93.24	55.62	30.90	.0000	.1886-002
410	406.89	12.93	3.94	7.07	2.15	204.52	95.84	57.05	31.69	.0000	.1955-002
415	417.20	13.11	3.99	6.89	2.10	209.33	98.52	58.54	32.52	.0000	.2025-002

Figure 3. continued

AREA	TIME AT DETECTION	TEMP. AT DETECTION	LAYER THICKNESS AT DETECTION	RATE OF RISE AT DETECTION	Q/00 AT DETECTION	DETECTABLE CONCEN. AT DETECTION	TIME AT HAZARD	TEMP. AT HAZARD	INTERFACE ELEVATION AT HAZARD	Q/00 AT HAZARD	HAZARDOUS CONCEN. AT HAZARD	AVAILABLE EGRESS TIME SEC
FT+2 (M+2)	SEC	DEG F (DEG C)	FT (M)	DEGF/M (DEGC/M)			SEC	DEG F (DEG C)	FT (M)			
420	427.76	13.28	4.06	6.72	2.08	214.28	101.27	60.09	33.38	.0000	.2096-002	
425	438.59	13.45	4.10	6.55	2.00	219.35	104.08	61.70	34.28	.0000	.2170-002	
430	449.69	13.62	4.16	6.38	1.94	224.56	106.98	63.38	35.21	.0000	.2246-002	
435	461.07	13.80	4.21	6.20	1.89	229.92	109.95	65.12	36.18	.0000	.2324-002	
440	472.74	13.97	4.26	6.03	1.84	235.42	113.01	66.94	37.19	.0000	.2404-002	
445	484.71	14.14	4.31	5.86	1.79	241.07	116.15	68.83	38.24	.0000	.2486-002	
450	496.95	14.32	4.36	5.68	1.73	246.89	119.35	70.79	39.33	.0000	.2570-002	
455	509.56	14.49	4.42	5.51	1.68	252.87	122.71	72.52	40.46	.0000	.2657-002	
460	522.46	14.66	4.47	5.34	1.63	259.03	126.13	74.93	41.63	.0000	.2747-002	
465	535.69	14.84	4.52	5.16	1.57	265.36	129.65	77.12	42.84	.0000	.2839-002	
470	549.25	15.01	4.58	4.99	1.52	271.88	133.27	79.39	44.10	.0000	.2934-002	
475	563.16	15.19	4.63	4.81	1.47	278.60	137.00	81.74	45.41	.0000	.3031-002	
480	577.41	15.37	4.68	4.63	1.41	285.51	140.84	84.17	46.76	.0000	.3132-002	
485	592.03	15.55	4.74	4.45	1.36	292.63	144.79	86.69	48.16	.0000	.3235-002	
490	607.02	15.73	4.79	4.27	1.30	299.96	148.87	89.29	49.61	.0000	.3342-002	
495	622.35	15.91	4.85	4.09	1.25	307.51	153.05	91.98	51.10	.0000	.3451-002	
500	638.14	16.10	4.91	3.90	1.19	315.29	157.39	94.76	52.64	.0000	.3564-002	
505	654.29	16.28	4.96	3.72	1.13	323.31	161.84	97.62	54.23	.0000	.3681-002	
510	670.56	16.47	5.02	3.53	1.08	331.57	166.43	100.56	55.87	.0000	.3801-002	
515	687.84	16.66	5.08	3.34	1.02	340.07	171.15	103.58	57.54	.0000	.3924-002	
520	705.25	16.86	5.14	3.14	.96	348.83	176.02	106.67	59.26	.0000	.4052-002	
525	723.11	17.05	5.20	2.95	.90	357.85	181.03	109.84	61.02	.0000	.4153-002	

MULTI-EXPONENTIAL FIRE GROWTH

5000.	0	71.98	.00	.13	1.00	.0000	523	355.46	3.00	718.33	.4148-002	523
(464.50)		(22.21)	(.00)	(.07)				(179.70)	(.91)			

Figure 3. continued

FLASHOVER POTENTIAL

AREA	TIME AT DETECTION	TEMP. AT DETECTION	LAYER THICKNESS AT DETECTION	RATE OF RISE AT DETECTION	DETECTABLE CONCEN. AT DETECTION	TIME AT HAZARD	TEMP. AT HAZARD	INTERFACE ELEVATION AT HAZARD	HAZARDOUS CONCEN. AT HAZARD	AVAILABLE EGRESS TIME
FT#2 (M#2)	SEC	DEG F (DEG C)	FT (M)	DEGF/M (DEGC/M)	0 AT DETECTION	SEC	DEG F (DEG C)	FT (M)	0 AT HAZARD	SEC
(9.29)	100.	0 (23.92)	.00 (.00)	6.96 (3.87)	2.00 .0000	306	750.00 (398.89)	.00 (.00)	.8940-.001	306
(11.15)	120.	0 (23.92)	.00 (.00)	6.48 (3.60)	2.00 .0000	314	750.00 (398.89)	.00 (.00)	.8940-.001	314
(18.58)	200.	0 (23.92)	.00 (.00)	5.53 (3.07)	2.00 .0000	337	750.00 (398.89)	.00 (.00)	.8940-.001	337
(23.22)	250.	0 (23.92)	.00 (.00)	5.24 (2.91)	2.00 .0000	348	750.00 (398.89)	.00 (.00)	.8940-.001	348
(27.87)	300.	0 (23.92)	.00 (.00)	5.05 (2.81)	2.00 .0000	357	750.00 (398.89)	.00 (.00)	.8940-.001	357
(37.16)	400.	0 (23.92)	.00 (.00)	4.81 (2.67)	2.00 .0000	372	750.00 (398.89)	.00 (.00)	.8940-.001	372
(46.45)	500.	0 (23.92)	.00 (.00)	4.67 (2.59)	2.00 .0000	384	750.00 (398.89)	.00 (.00)	.8940-.001	384
(55.74)	600.	0 (23.92)	.00 (.00)	4.57 (2.54)	2.00 .0000	395	750.00 (398.89)	.00 (.00)	.8940-.001	395
(74.32)	800.	0 (23.92)	.00 (.00)	4.45 (2.47)	2.00 .0000	415	750.00 (398.89)	.08 (.02)	.8940-.001	415
(92.90)	1000.	0 (23.92)	.00 (.00)	4.38 (2.43)	2.00 .0000	436	750.00 (398.89)	.51 (.15)	.8940-.001	436
(111.48)	1200.	0 (23.92)	.00 (.00)	4.34 (2.41)	2.00 .0000	459	750.00 (398.89)	.86 (.26)	.8940-.001	459

Figure 4. Computer output from batch run of Example 3

2000.	0	75.06	.00	4.24	2.00	.0000	812	750.00	1.72	49.91	.8940-001	312
(185.80)	(	(23.92)	(.00)	(2.36)				(398.89)	(.52)			

--THE UPPER LIMIT OF THE DIGITAL DATA HAS BEEN EXCEEDED.
CONTINUE WITH THE NEXT COMPARTMENT HEIGHT OR SPECIFIED
DETECTION CRITERIA.--

Figure 4. continued

FLASHOVER POTENTIAL

AREA	TIME AT DETECTION	TEMP. AT DETECTION	LAYER THICKNESS AT DETECTION	RATE OF RISE AT DETECTION	Q AT DETECTION	DETECTABLE CONCEN. AT DETECTION	TIME AT HAZARD	TEMP. AT HAZARD	INTERFACE ELEVATION AT HAZARD	Q AT HAZARD	HAZARDOUS CONCEN. AT HAZARD	AVAILABLE EGRESS TIME
FT**2 (M**2)	SEC	DEG F (DEG C)	FT (M)	DEGF/M (DEGC/M)	KW		SEC	DEG F (DEG C)	FT (M)	KW		SEC
(100. 9.29)	0	72.16 (22.31)	.00 (.00)	2.76 (1.53)	2.00	.0000	330	750.00 (398.89)	.00 (.00)	601.72	.8940-001	330
(120. 11.15)	0	72.16 (22.31)	.00 (.00)	2.47 (1.37)	2.00	.0000	338	750.00 (398.89)	.00 (.00)	689.86	.8940-001	338
(200. 18.58)	0	72.16 (22.31)	.00 (.00)	1.90 (1.06)	2.00	.0000	366	750.00 (398.89)	.00 (.00)	961.69	.8940-001	366
(250. 23.22)	0	72.16 (22.31)	.00 (.00)	1.73 (.96)	2.00	.0000	379	750.00 (398.89)	.00 (.00)	1095.42	.8940-001	379
(300. 27.87)	0	72.16 (22.31)	.00 (.00)	1.62 (.90)	2.00	.0000	391	750.00 (398.89)	.00 (.00)	1191.44	.8940-001	391
(400. 37.16)	0	72.16 (22.31)	.00 (.00)	1.48 (.82)	2.00	.0000	415	750.00 (398.89)	.00 (.00)	1031.40	.8940-001	415
(500. 46.45)	0	72.16 (22.31)	.00 (.00)	1.39 (.77)	2.00	.0000	442	750.00 (398.89)	.00 (.00)	847.96	.8940-001	442
(600. 55.74)	0	72.16 (22.31)	.00 (.00)	1.33 (.74)	2.00	.0000	476	750.00 (398.89)	.00 (.00)	619.93	.8940-001	476
(800. 74.32)	0	72.16 (22.31)	.00 (.00)	1.26 (.70)	2.00	.0000	656	750.00 (398.89)	.00 (.00)	103.27	.8940-001	656

--THE UPPER LIMIT OF THE DIGITAL DATA HAS BEEN EXCEEDED.
CONTINUE WITH THE NEXT COMPARTMENT HEIGHT OR SPECIFIED
DETECTION CRITERIA.--

Figure 4. continued

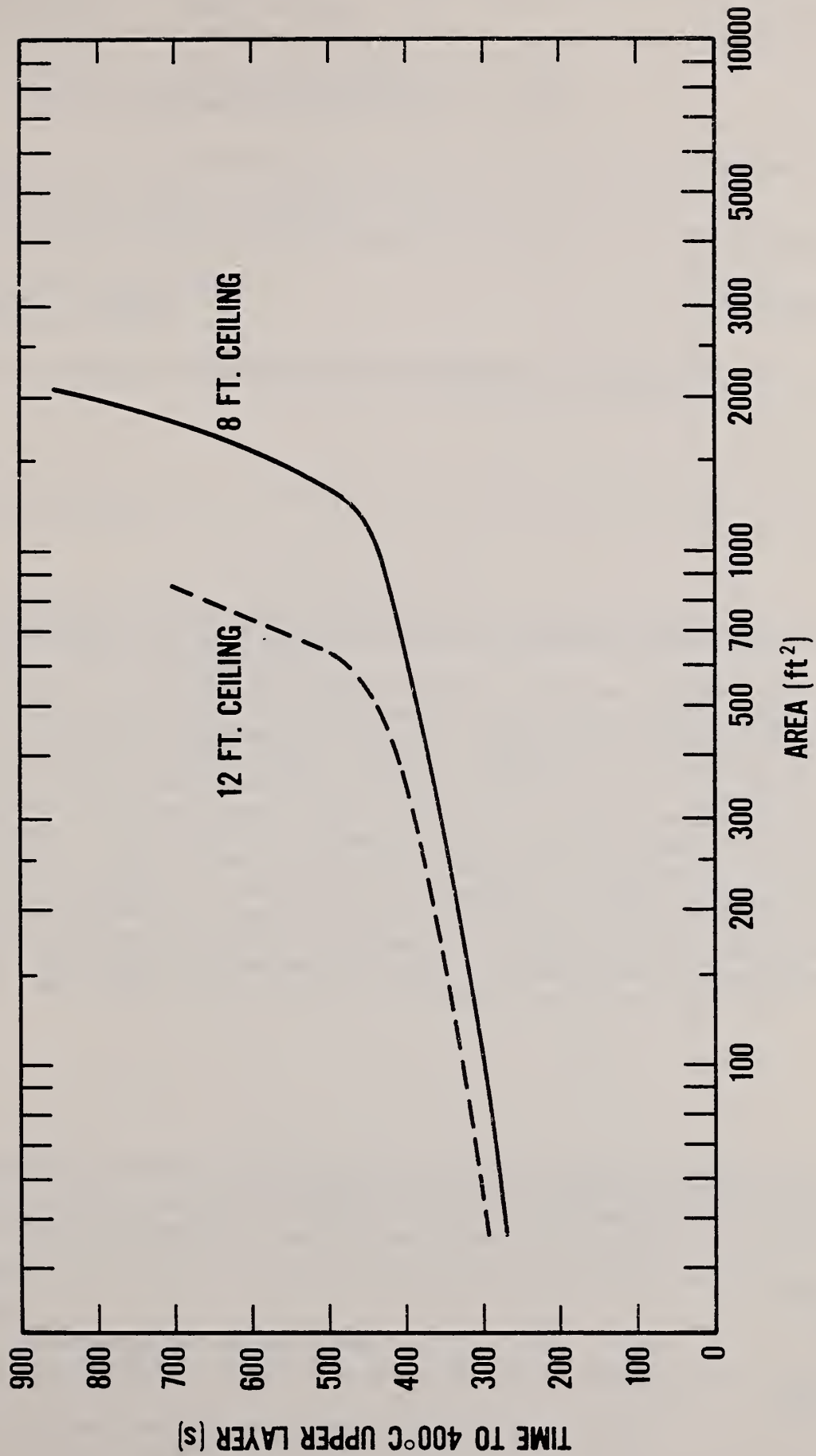


Figure 5. Example 3 results: plot of time to reach potential flashover against enclosure floor area, for a fire confined to an assembly of bedding combustibles

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. NBSIR 82-2578	2. Performing Organ. Report No.	3. Publication Date September 1982
4. TITLE AND SUBTITLE CALCULATING AVAILABLE SAFE EGRESS TIME (ASET) - A COMPUTER PROGRAM AND USER'S GUIDE			
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10. SUPPLEMENTARY NOTES ☒ Document describes a computer program; SF-185, FIPS Software Summary, is attached.			
11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here) In the event of a fire in a building compartment the time available for occupants to safely evacuate the compartment, the Available Safe Egress Time (ASET), depends on the time of fire detection and on the time of the onset of hazardous conditions. In order to estimate these two times a dynamic simulation of the developing fire environment in the compartment is required. Also required are specific criteria for the simulation of detection and onset of hazard. A user oriented computer program which carries out the required simulations and provides estimates for the ASET has been developed. This document provides a listing of the program and a manual for its use. For fire growth in a particular fuel assembly, a single program run can be used to evaluate the ASET from enclosures (which are assumed to contain the fuel assembly) of different heights and areas, and under a variety of different detection and hazard criteria. The program can be used in either an interactive or batch mode. It is written in ANSI Fortran and requires no computer specific subroutines.			
12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons) Combustion products; compartment fires; egress; fire detection; fire growth; hazard analysis; mathematical models; room fires; smoke movement; tenability limits.			
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